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ABSTRACT

This book is about changes in the Chesapeake Bay, its animals, plants, and the surrounding land during the last 15,000 years. Some changes were caused by natural forces while others were made by people. "Chesapeake Challenges" tests the student's thinking skills. "Family Action" lists things families can do to learn more about the Chesapeake Bay region. The book tells the reader how to be a component of the Chesapeake Bay's future by understanding why the Bay is in trouble and how each person can help. Sections of the book include: (1) "The Chesapeake Bay before European Settlement"; (2) "The Natural History of the Chesapeake Bay"; (3) "Map of the Chesapeake Bay and Its Watershed"; (4) "Changes in the Chesapeake Bay and its Watershed Caused by European Settlement"; and (5) "The Chesapeake Bay Today." The volume concludes with an information section for parents and teachers. The handbook is designed to complement the National Aquarium's publication, "Living in Water." (EH)

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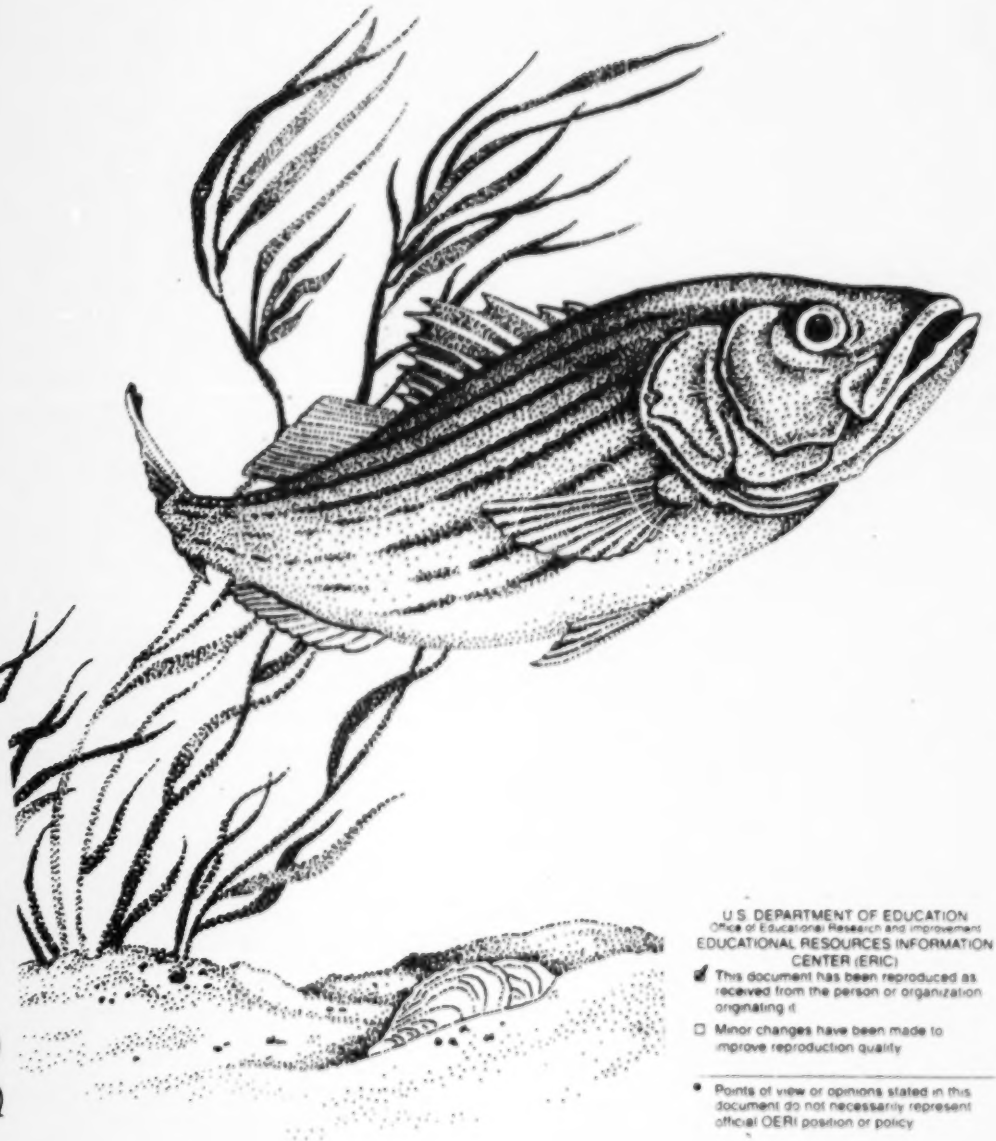
THE CHANGING CHESAPEAKE



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an introduction to the natural history and cultural history of the Chesapeake Bay

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This booklet was written by Valerie Chase, Ph.D., staff biologist at the National Aquarium in Baltimore, and designed and illustrated by Cynthia A. Belcher, as part of a joint project between

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The Changing Chesapeake
INTRODUCTION

The Chesapeake Bay is changing; many of its plants and animals are in danger.

Everything changes with time. Many human activities cause change. Some changes happen very fast. A forest fire set by a person destroys thousands of acres of trees in a day. It takes longer to remove a forest by cutting the trees for lumber, but the forest is still lost. Some changes are caused by building. A farm disappears as houses cover its fields. The course of history changes in an instant when a leader like John F. Kennedy or Martin Luther King, Jr. is killed. The actions of people who live around the Chesapeake Bay have changed the Bay.

Change may also be caused by natural events. Sometimes it is fast. An earthquake changes land in an instant. A volcanic eruption destroys thousands of acres of forest. A hurricane changes an entire coastline overnight. Other natural changes are so slow that we use special instruments to detect them. The movement of continents and the wearing down of mountains show this very slow change.

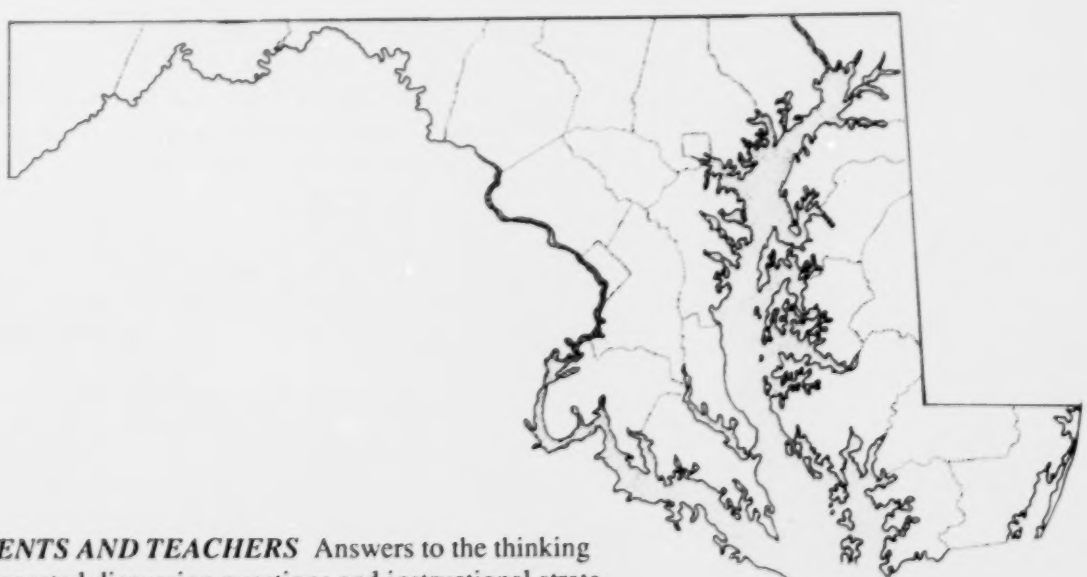
This book is about changes in the Chesapeake Bay, its animals and plants, and the surrounding land in the last 15,000 years. Some were caused by natural forces while others are made by people. The changes that endanger the Chesapeake Bay are a part of our past. The changes that we must make to save the Bay are in our future. This book lets you be a part of the Chesapeake Bay's future by understanding why the Chesapeake Bay is in trouble and how you can help.

Chesapeake Challenges and Family Action

As you go through this book, you will meet **Chesapeake Challenges** which test your thinking skills. **Family Action** lists things to do with your family that will help you to learn more about the Chesapeake Bay region. Find the exact location of places to visit by looking in books on day trips in the travel section of your library. They will tell you more and give exact locations. If you are using this book with your teacher or parents, Parent/Teacher Discussions will help increase your understanding of important Bay issues. If you do not have a map of your state, request one from:

MARYLAND Tourism
1-800-543-1036

VIRGINIA Department of Transportation
1401 E. Broad St.
Richmond, VA 23219



NOTE TO PARENTS AND TEACHERS Answers to the thinking skills questions, suggested discussion questions and instructional strategies, and information on ways to use this booklet with ***Living in Water,*** an aquatic science curriculum for upper elementary/middle school grades from the National Aquarium in Baltimore, are located on pages 57-60.

TABLE OF CONTENTS

Introduction 1

The Chesapeake Bay before European Settlement 3
The End of the Last Ice Age 4
Map of the Chesapeake Bay Shorelines 5
Climate Change in the Future 6
The Land Changed as the Bay Formed 7
The First Americans: Changing Ways of Life 8
The Chesapeake Bay as Seen by the Europeans 9
Native Americans of the Chesapeake Bay Region 10
Native Americans and their Environment 11

The Natural History of the Chesapeake Bay 12
The Chesapeake Bay and its Watershed 13
The Chesapeake Bay Watershed 14
The Chesapeake Bay's Salt Water 15
What is Special About an Estuary? 16
Tides in the Chesapeake Bay 17
Chesapeake Habitats 18
Classifying Habitats of the Chesapeake Bay 19
Chesapeake Bay Food Chains 23
Zooplankton in the Chesapeake Bay 24
Blue Crabs in the Chesapeake Bay 25
Map of the Chesapeake Bay 26
Oysters 27
Atlantic Menhaden 28
Striped Bass 29

Map of the Chesapeake Bay and its Watershed 30

Changes in the Chesapeake Bay and its Watershed Caused by European Settlement 32
European Settlement of the Chesapeake Bay 33
Growing Tobacco 34
The Force of Moving Water 35
Using Water Power 36
Travel and Trade in Early Times 37
Working Boats and Ships of the Chesapeake Bay 38
Fishing the Bay 42

The Chesapeake Bay Today 43
Habitats in the Chesapeake Bay Watershed Today 44
Muddy Water 48
Too Many Nutrients 49
Toxic Materials in the Bay 50
Too Many Phytoplankton and No Oxygen 51
Lost Underwater Grass Beds 52
The Problem is People 53
Meeting the Challenge 54
Forests to Help the Bay 55
What Can Just One Kid Do? 56

Parent/Teacher Information 57

The Chesapeake Bay before European Settlement

Many changes took place in the Chesapeake Bay and the land surrounding the Bay before Europeans settled here. Some of these changes were caused by natural events. One change was the arrival of the first Americans who came not from Europe, but from Asia.

Chesapeake Challenge

1. Color the spaces on the map of the old Chesapeake Bay on page 5 to see the changes in the shape of the Chesapeake Bay from a river valley 15,000 years ago to the Bay as it is today. Use blue for the river 15,000 years ago and green for the Bay 3,000 years ago.

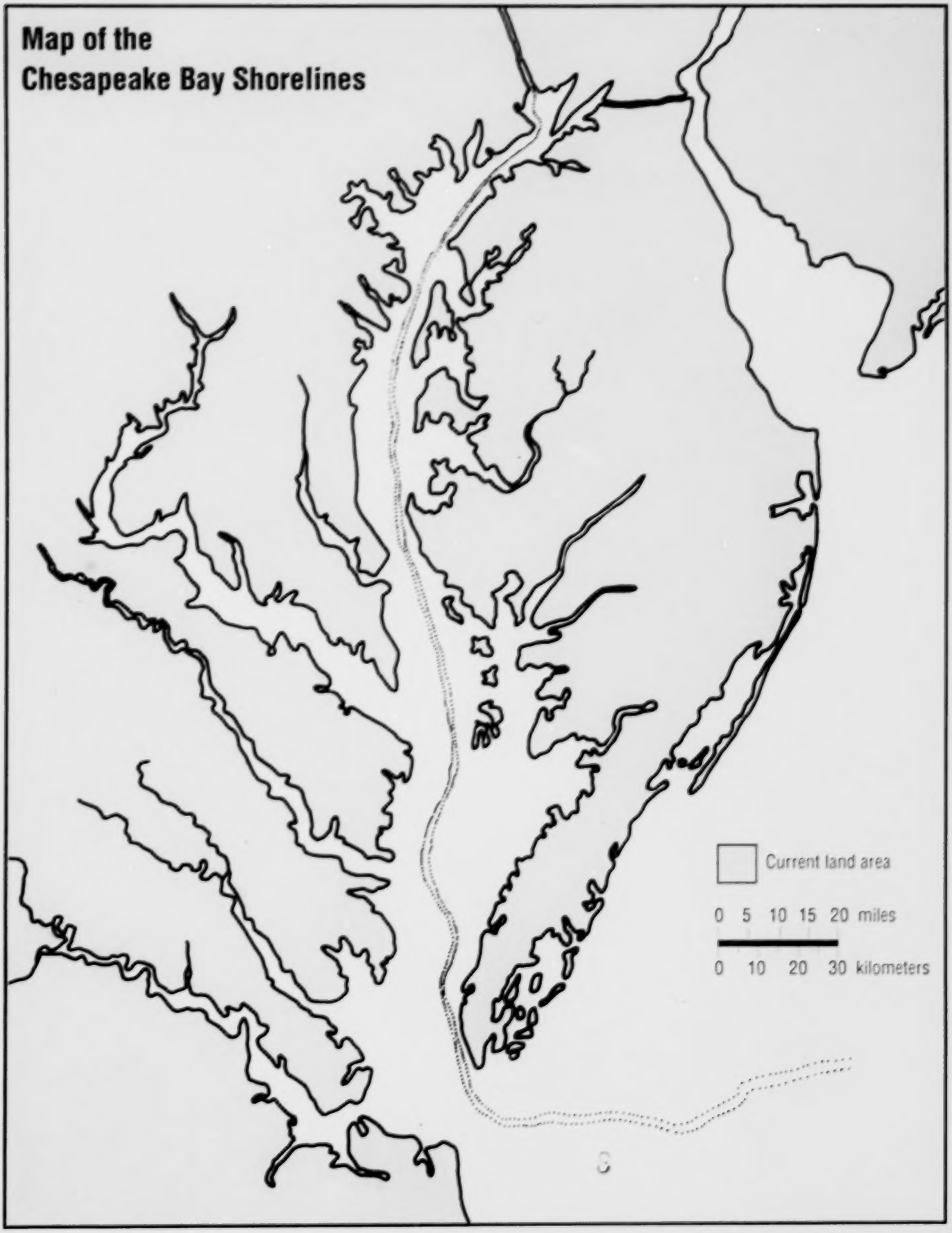
2. If you lived where you do now 8,000 years ago, would you have been nearer or farther from the shore of the Bay than you are today?

The End of the Last Ice Age

Four times during the last million years the great sheets of ice that cover the polar region have slowly grown across Canada and down into the United States. Only 20,000 years ago ice more than 180-200 m (600-700 ft) covered much of New York and Pennsylvania and even extended into parts of Maryland. These periods are called the Ice Ages. In between these Ice Ages the Earth's climate warmed, and the ice melted. We are living during the warm period that followed the last Ice Age. Earth scientists (geologists) do not know for sure what caused these changes between warm and cold climates.

The water that formed the ice came from the ocean. When so much water was locked up as ice, sea level was much lower. Twenty thousand years ago sea level was 100 m (330 ft) lower than it is today. Where the Chesapeake Bay is now, there was a valley created by the Susquehanna River which flowed down the valley and into the Atlantic Ocean.

Eighteen thousand years ago the Earth's climate began to warm slowly. As the ice melted, sea level rose. By 10,000 years ago the ocean began to flood the lower Susquehanna Valley. By 3,000 years ago, the shores of the Chesapeake Bay were almost where they are today. Even today sea level is still rising, but very slowly. Over the last 100 years it has gone up at the rate of about 1 mm per year or about 4 inches in 100 years.


Map of the
Chesapeake Bay Shorelines
Current land area
0 5 10 15 20 miles
0 10 20 30 kilometers

Chesapeake Challenge

1. Use the estimate given here to calculate how much sea level may rise in 60 years, during your life.

Family Action

1. Working together, list all the ways that you and your family make carbon dioxide. Can you think of some ways that you and your family could change your way of life to decrease the amount of carbon dioxide you make?

2. In addition to reducing the fossil fuel you use, your family can help reduce the carbon dioxide in the atmosphere by planting trees in your yard. Growing trees use carbon dioxide which they get from the atmosphere.

Climate Change in the Future

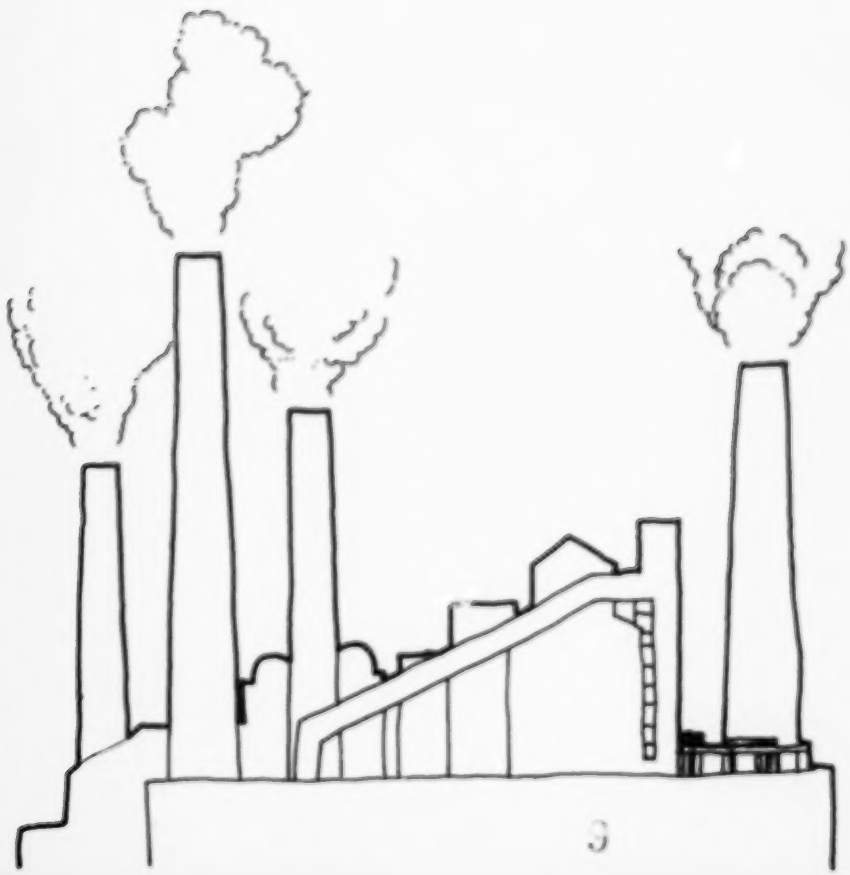
Scientists do not know what caused the changing pattern of cold and warm climates that caused the Ice Ages. The different ideas about the causes of the warming and cooling are called theories. Since it is not possible to test these theories, we may never know for sure.

On the other hand, scientists often look to the future with guesses about what will happen based on their observations of current and past events. These guesses are called predictions. One of the most important predictions for future change is increased heating of the Earth caused by increasing amounts of carbon dioxide in the Earth's atmosphere.

People cause this change. We burn fossil fuels such as natural gas, coal, and oil to cook our food, heat our homes, run our cars and make most of our electricity. Wood, the most common fuel for people in poor countries, also releases carbon dioxide when it burns. Cutting and burning forests to clear land adds more.

Carbon dioxide gas absorbs the heat from the Sun. It also traps heat that the Earth would lose to space. This trapping of heat is commonly called the "greenhouse effect" because it reminds people of the way a greenhouse warms up on a cold, sunny day.

The Earth's atmosphere is getting warmer. What do we know from the past about warm periods? As the climate heats up, more ice melts at the North and South Poles. Sea level will start rising faster than the current 1 mm per year. Predictions are as much as 2.5 cm (1 in) per year.



The Land Changed as the Bay Formed

As the climate warmed and sea level rose, the plants and animals on the land around the Chesapeake Bay changed too. During the last Ice Age, the forests were similar to those that are now found in Canada. The trees were mostly spruce, fir and hemlock, whose needles remain green all year (evergreen). There were lush meadows and marshes on the bottom of what is now the Chesapeake Bay and on the continental shelf along the coast of the Atlantic Ocean.

Large plant-eating mammals roamed these meadows. They included the elephant-like mammoths and mastodons as well as bison, moose and elk. None of these animals are found in the Chesapeake Bay region today. Elk and moose moved north as the climate warmed. Mastodons and mammoths died out (became extinct). They may not have been able to survive the changing climate. The eastern forest bison survived until Europeans arrived. Then they were hunted to extinction. What evidence do we have that these animals were here? Fossil bones and teeth have been found on the bottom of the Chesapeake Bay and along the continental shelf.

Where did the Ice Age forests go? As the climate changed, each generation of seedlings grew a little further north or a little higher in the mountains where it was still cool. These same evergreen trees now grow in Canada and along the tops of the mountains in the eastern United States. They were replaced in most of the Chesapeake Bay region by trees that lose their leaves in winter such as oaks, hickories, beech and chestnuts. This area was covered in vast forests when the first Europeans arrived.

Chesapeake Challenge

1. Plants and animals die out or become extinct for many reasons. List two causes of extinction mentioned here.

2. The Ice Age forests moved slowly north to Canada over thousands of years. Predict what might happen to plants and trees in the Chesapeake region in the future if the climate changes rapidly due to the greenhouse effect.

Family Action

1. Explore a tiny bit of Maryland that has survived from the Ice Age: Cranesville Sub-Arctic Swamp owned by the Nature Conservancy and located on the border with West Virginia.

2. Discover what those Ice Age animals looked like. The Smithsonian Institution's Museum of Natural History has exhibits on these animals in the Hall of Evolution.

mammoth

Chesapeake Challenge

1. Imagine that you were living in a village on the shore of the Chesapeake Bay before Europeans came here. List the things your village site would need to make it a good place to live.

2. Imagine that you were an Indian child of your own age living in a village before Europeans came. List three things that you might do to have fun.

Family Action

1. Visit a museum that features the history of Native Americans such as the Smithsonian Institution's Museum of Natural History.

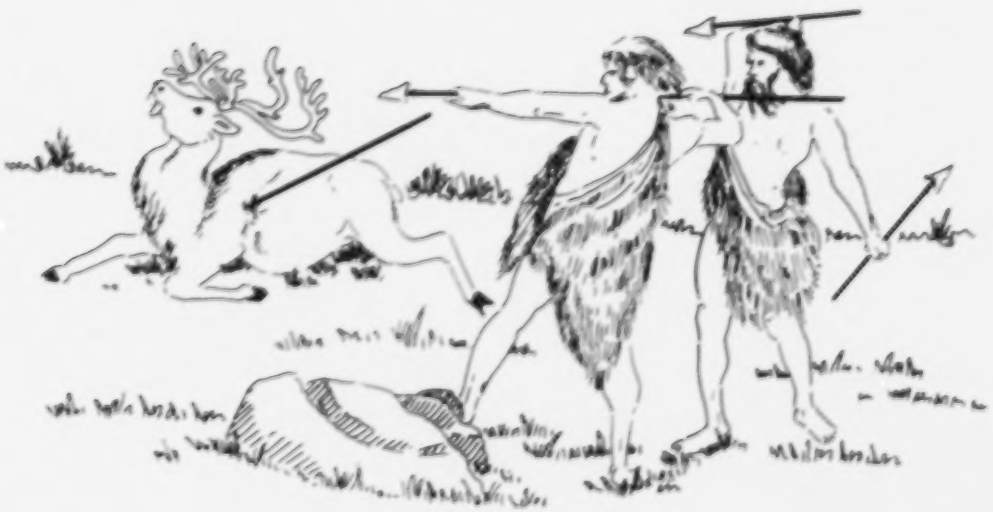
2. Go camping and leave as much modern technology as possible at home.

The First Americans: Changing Ways of Life

The first Americans came to North and South America from Asia by walking across the land bridge exposed by lower sea level that joined Siberia and Alaska during the last Ice Age. Archaeologists are scientists who study human life before recorded history. They are still uncovering new discoveries about these first Americans. They have evidence that people lived along the Susquehanna River as the Bay filled six thousand years ago.

These first Americans hunted the mammoths, bison and caribou using throwing sticks (also called atlatls) and spears as weapons. They followed the herds of animals, hunting and gathering nuts, berries and other foods as they moved. Periodically the scattered small bands gathered to trade and socialize.

The climate warmed and the herds of large animals disappeared as the forests changed and grew. The people living in the Chesapeake region also changed. They learned to hunt smaller game and work with wood. They gradually came to live in settled villages and to grow and harvest crops. The most important were corn, beans and squash. They also grew strong tobacco which they smoked in pipes. A number of groups lived in scattered villages in the Chesapeake region when the first Europeans reached North America. Thinking they had reached the Indies (a region in Asia) the Europeans called these people Indians. Today they are also called Native Americans.



The Chesapeake Bay as Seen by the Europeans

The Spanish first settled in the New World in 1494 in the Caribbean. By 1524 they had explored the Chesapeake Bay. It was the English who founded settlements on the Chesapeake Bay, however. In 1607 they founded Jamestown. From that village Captain John Smith led explorations of the Bay and its surrounding land. These are his descriptions of the Bay and the people he found living there. (Spelling was not the same in 1607 as now. It is changed enough for you to read.)

Of the Chesapeake Bay he wrote:

"There is but one entrance by Sea into this Country, and that is at the mouth of a goodly Bay, 18 or 20 myles broad."

"Here are mountaines, hils, plaines, valleyes, rivers and brookes, all running most pleasantly into a faire Bay, compassed but for the mouth, with fruitfull and delightsome land."

"Virginia doth afford many excellent vegetables, and living Creatures, yet grasse there is little or none, but what grow in the low Marishes: for all the Countrey is overgrowne with trees,"

Of the Native Americans he wrote:

"In March and Aprill they live much upon their fishing weires; and feed on fish, Turkies, and Squirrels. In May and June they plant their fields, and live most of Acornes, Walnuts, and fish. But to amend their dyet, some disperse themselves in small companies, and live upon fish, beasts, crabs, oysters, land Tortoises, strawberries, mulberries, and such like. In June, July, and August, they feed upon roots, berries, fish, and greene corne.

"The men bestow their times in fishing, hunting, warres, and such man-like exercises, scorning to be seene in any woman-like exercise, which is the cause that the woman be very painefull, and the men often idle. The women and children doe the rest of the worke. They make mats, baskets, pots, morters, pound their corne, make their bread, prepare their victuals, plant their corne, gather their corne, beare all kinds of burdens, and such like."

Chesapeake Challenge

1. What evidence in the writing of Captain Smith can you find for the importance of the Bay in providing food for the Indians?

2. What evidence do you find for Smith's opinion about the role of Native American women? Do you think the role of women among the European settlers was different? What about the role of women today in your community?

3. Write a page from an imaginary journal written by a member of Captain Smith's company as they explored the Bay.

an early map of Virginia and a European view of Native Americans

Chesapeake Challenge

1. Use a map of your state to find five Native American names for places near you. Each name had a meaning. For example, Choptank means "it flows in the opposite direction" referring to the tidal nature of the Choptank River. Use the library to find the meaning of the names you found.

2. Have you ever fished using a means similar to one the Indians used? What did you do? Describe it.

3. Make a model of a weir used to trap fish swimming upstream.

Family Action

1. Go fishing on the Chesapeake Bay or one of its rivers.

2. Contact a local nature center to see if it sponsors canoe trips. Many museums and nature centers have canoe trips, even for those who do not know how. If you can canoe, look for places to rent canoes or go canoeing in the *Audubon Guide to the Mid-Atlantic States.*

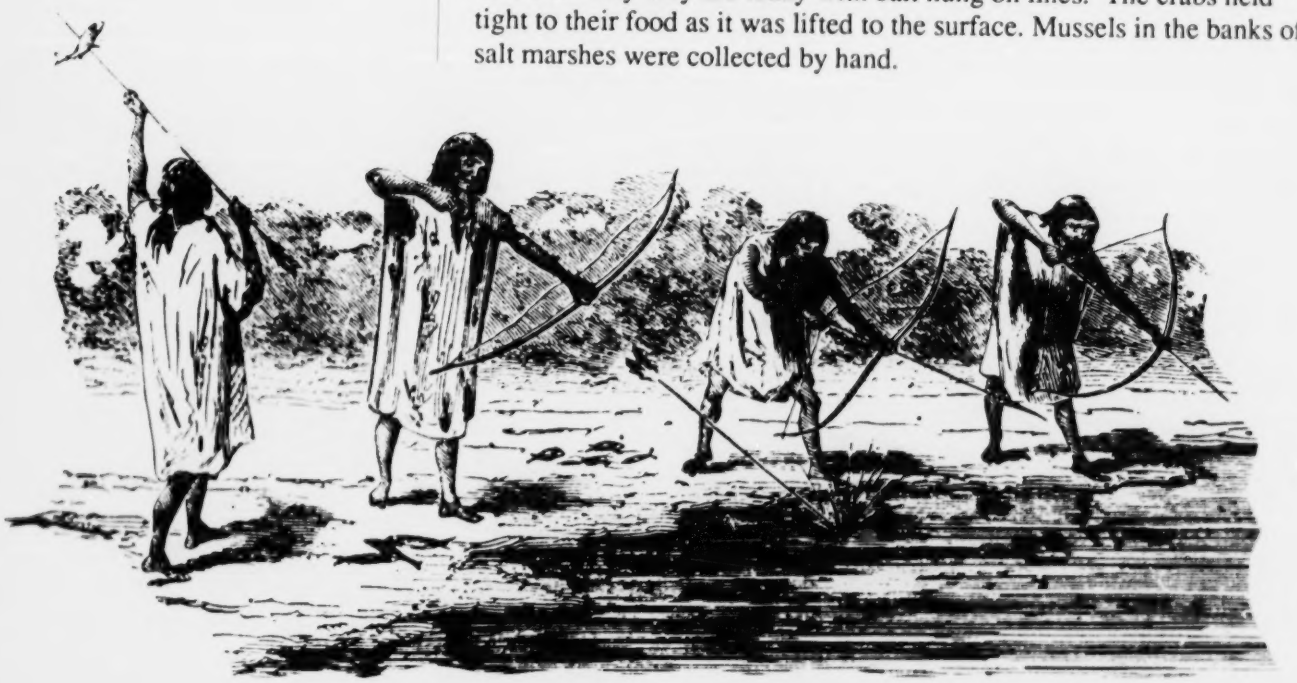
Native Americans of the Chesapeake Bay Region

Archaeologists estimate that there were 65-150,000 people living in small villages in the Bay region when Europeans first landed there. Captain John Smith generally recorded only the number of adult males in each group he met. The numbers ranged from 20-300. Most had fewer than 100. Many shared the same language. There were forty or more villages in Delaware and Maryland alone. Rivers and the Bay often formed the dividing line between groups. Today about all that remains of these people are the Native American names we use each day for our streets, towns, schools, rivers and the Bay itself. Chesapeake means great shellfish bay.

The Chesapeake Bay provided many kinds of food for the Indians, as you learned from reading Captain John Smith's words. They harvested these animals in ways that showed an understanding of the biology of each species. Many of their ways of fishing are still in use today.

Some kinds of fish were caught with baited hooks made of bone attached to lines of deer sinew or grasses. They also shot fish with arrows attached to lines or speared them from log canoes. When fishing at night, they used a small fire in the canoe. Many fish swim into or out of the Bay seasonally in large numbers. Those that swim up streams to lay their eggs were caught in weirs, traps made of poles and fibers that went across the stream. They also made traps of poles along the shore to catch fish swimming up or down the Bay. Fish and other animals were also taken in a hand-held net on a pole.

The Indians collected oysters and clams. Blue crabs were caught much the way they are today with bait hung on lines. The crabs held tight to their food as it was lifted to the surface. Mussels in the banks of salt marshes were collected by hand.



Native Americans and their Environment

The Indians did not do much damage to their environment. There were not very many of them. There may have been no more that 65-150,000 Native Americans in the entire Chesapeake Bay watershed. When their fields were worn out, they could move to a new place and the forest would slowly take over the old fields. Likewise, if the garbage and human waste near a village became too great, they could move. The natural process of decay broke down the harmful parts, leaving only bits behind. Much of what we know about their way of life comes from sifting through the trash they left behind. Animal bones and plant remains tell us what they ate. Broken tools and pieces of pots and baskets tell us about their technology and culture.

Their tools were made of natural things: stone, bone and wood. Their fishing nets and lines were made of plant and animal fibers. Some kinds of damage they did actually helped keep the numbers of kinds of plants and animals high. They drove large game to hunters using fire. We now know that regular burning is needed by some kinds of plants and habitats. After years of preventing forest fires, we have lost plants like the longleaf pine which needs fire to compete with other pines.

Native Americans were skillful fighters. European settlers learned ways to fight from them that later helped win the Revolutionary War. But they lacked weapons of iron, steel, and gunpowder. Perhaps more important, the Europeans brought many new diseases with them which were deadly for the Indians, such as measles and small pox. By 1756, war, disease and migration had reduced Maryland's Indian population to 140 persons. A few Indians adapted to the European ways. John Rolfe, the man who started growing tobacco in Virginia, married the Indian woman Captain John Smith called Pocahontas. Many of us have Indians among our ancestors. Today there are still a few Native Americans living in the Chesapeake Bay region who preserve their heritage.

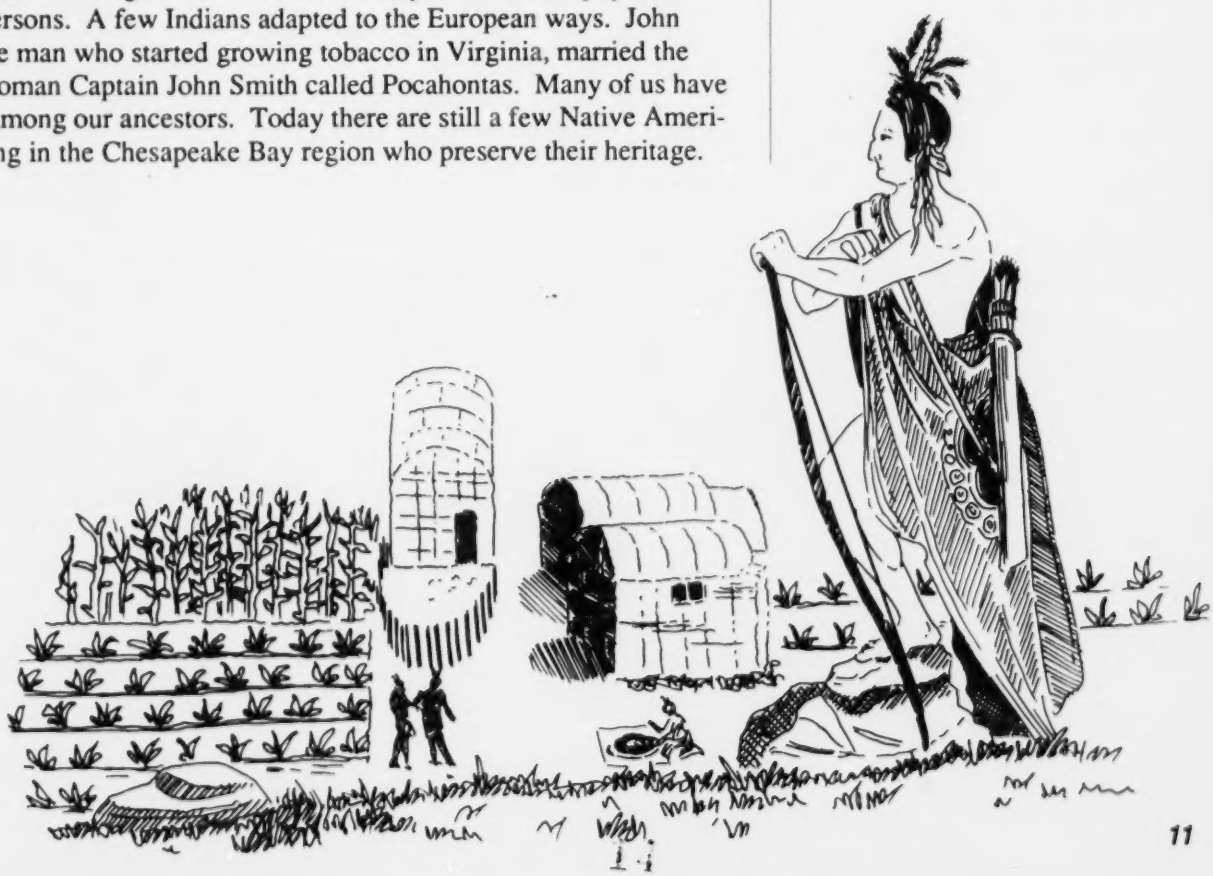
Chesapeake Challenge

1. Visit the library and research a Native American tribe of the Chesapeake region. The Powhatan, Piscataways, and Nanticokes are several you might look for. Generally, there were villages with names similar to many of the Bay's rivers. Write a short story about one day in the normal life of these people. Include the ways they used the Bay or a river in the story.

2. Compare the way the Native Americans used the Bay with our use of it today. Many of the uses are the same, but we are hurting the Bay while they did not. Can you list two reasons why?

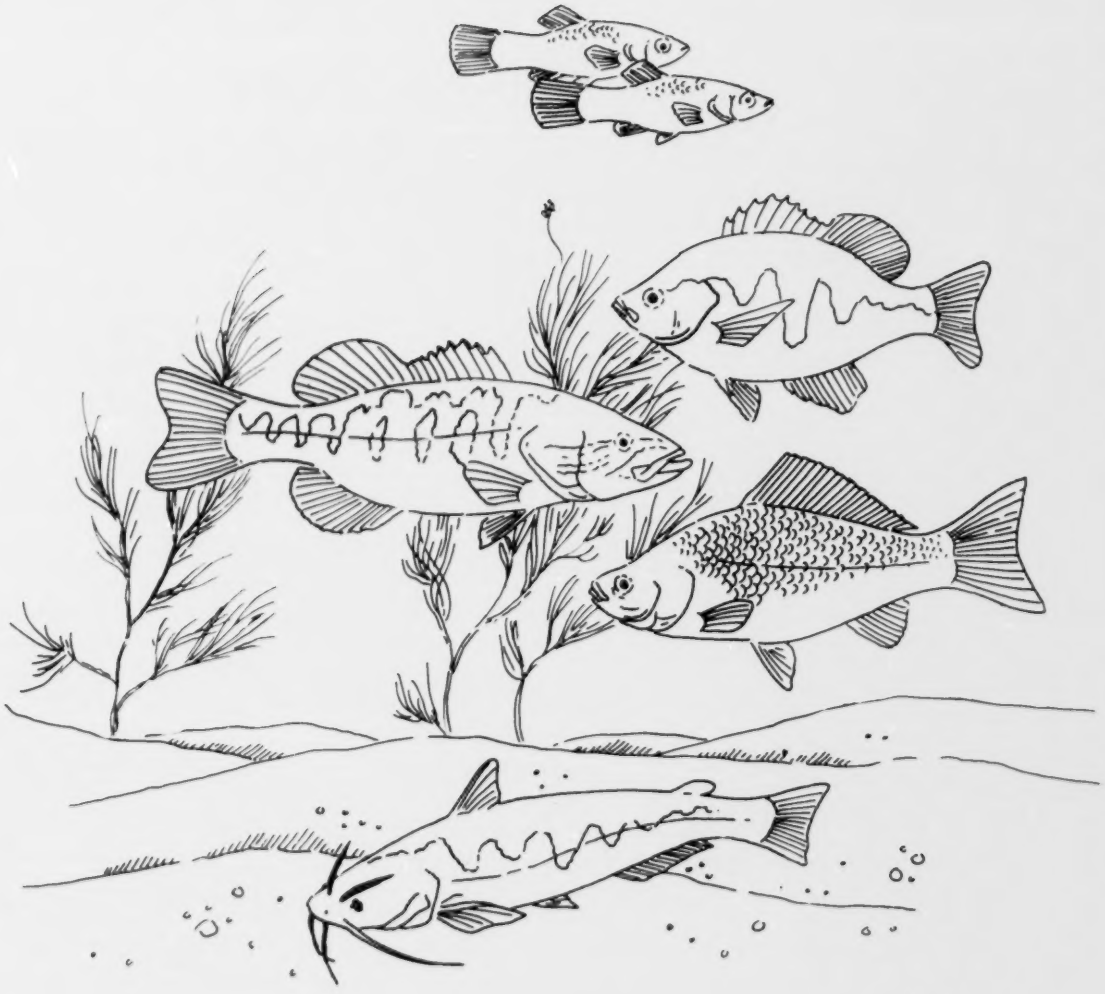
Family Action

1. Check the contents of your garbage cans. The paper and other vegetable material will rot in time. What would someone be able to say about your family and your way of life by examining what would remain of your garbage in 1,000 years?



The Natural History of the Chesapeake Bay

In order to understand and measure the changes in the Chesapeake Bay's plants and animals, we need to know how they live under natural, undisturbed conditions.



The Chesapeake Bay and its Watershed

The flooded Susquehanna River valley formed an estuary. An estuary is a somewhat closed body of water where fresh water mixes with salt water. An estuary opens into the ocean which is the source of the salt water. The fresh water comes from rain or snow that falls onto the land and then drains away in streams, or comes from springs that bring groundwater to the surface. Both join to become rivers that flow into the estuary.

The Chesapeake Bay is enclosed by Delaware and the eastern parts of Maryland and Virginia. On the western side are rolling hills and, farther away, the Appalachian Mountains. The Bay's opening to the Atlantic Ocean is in southern Virginia. The fresh water for the Bay comes from many rivers which drain about 64,000 square miles spread over five states. The land which drains into the Chesapeake is called its watershed. Everything that gets into the water anyplace in the watershed of the Chesapeake Bay eventually ends up in the Bay.

Chesapeake Challenge

1. Look at the map. List the six states in the watershed of the Bay.

2. On the map on pages 30 and 31 find and write in the names of these rivers that drain into the Bay:

Susquehanna River
Patapsco River
Potomac River
Patuxent River
Rappahannock River
York River
James River
Choptank River
Nanticoke River

3. Do you think more water enters the Chesapeake Bay from the eastern side or the western side? What evidence would you give for your answer?

Family Action

1. Locate where you live on a map. Find the stream or river nearest your home that flows into the Chesapeake Bay. Drive, walk, ride a bus or bicycle to it. Sit beside the stream and think about the travels this water will make to the Bay. Imagine yourself floating along for the ride the way a leaf might. Does it look clean or dirty? Can you think of anything your family could do to help it? Later you will know lots of ways to help this stream or river. For now perhaps your family could pick up any trash you see and dispose of it properly.

2. If you live in a city, locate the storm drain nearest your home. This drain carries rain and melted snow to waterways that empty into the Bay. Is there trash in the street? Anything that goes into this drain will end up in the Bay, including all the trash. You can help keep the Bay clean by not throwing trash.

Chesapeake Challenge

1. Make a model of a watershed to see how small streams join to become rivers and flow into a bay. You will need:

- a baking pan or large plastic tray
- a sheet of aluminum foil the length of the pan
- blocks, rocks or other objects to be mountains
- a sprinkling can or another way to make "rain" such as a paper cup with holes in the bottom
- water

Put the blocks at one end of the pan for mountains. Lay the foil in the pan on top of the blocks. Press valleys between the mountains which join and form a bay at the end away from the mountains. Use the sprinkling can to make rain in the mountains. (This activity is used with permission and comes from *River Times* published by the Math and Science Center, 2401 Hartman St., Richmond, Virginia 23223.)

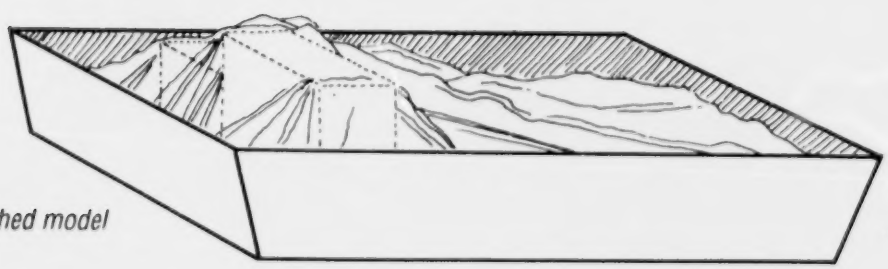
2. Describe the way the water moves in your watershed.

3. Study the way plant nutrients collect in the Bay. Sprinkle 1/4 teaspoon of a dark flavor of Kool-Aid over your watershed to represent plant nutrients. Describe what happens to these plant nutrients when you make it rain. The same things happens to plant nutrients and loose dirt when it rains.

The Chesapeake Bay Watershed

Two things may happen to the rain and snow that falls on the Chesapeake Bay watershed, the land that drains into the Bay. Some of the water runs over the land directly into streams and rivers and is called runoff. The rest of the water soaks into the soil and moves down through soil and rock until it reaches the groundwater where the spaces in the rock layers are full of water. When the groundwater meets the surface of the earth, the water runs out as springs which also flow into streams and eventually into the Bay. People tap into the groundwater when they dig a well.

Both runoff and the water that soaks down through the soil picks up natural chemicals from the soil that dissolve into water. You cannot see them, but they are there in small amounts. Some of these chemicals are things that help plants grow and are called plant nutrients. They are the same things that are in fertilizer used in a vegetable garden or "plant food" for a houseplant. Streams and rivers carry these plant nutrients into the Bay where they help make the Chesapeake Bay a good place for plants that live in water.



watershed model

The Chesapeake Bay's Salt Water

Water that does not taste salty is called fresh water. Water that comes from the ocean tastes salty because it has different kinds of chemicals called salts in it. Ocean water is also called sea water or salt water.

When fresh water and sea water mix, the saltiness is lower than that of the ocean. This mix of fresh and salt water is called brackish water. The saltiness of brackish water varies from hardly any salt to almost as much as salt water. Most of the water in the Bay is brackish, but the amount of salt varies from place to place.

Because the Bay is partly enclosed by land, fresh water and salt water meet and mix there. Fresh water in the Chesapeake Bay comes from rivers, so the water is less salty at the mouths of rivers. Salt water from the Atlantic Ocean flows into the Bay at its opening in southern Virginia so the Bay is saltier farther south.

Because fresh water is lighter than salt water, the fresh water floats above salt water. That means that if you test for the amount of salt in the water (the salinity) in one place from top to bottom, the Bay will be less salty at its surface and more salty on the bottom. All of this means that saltiness or salinity of the Bay's water varies from north to south and from top to bottom.

Chesapeake Challenge

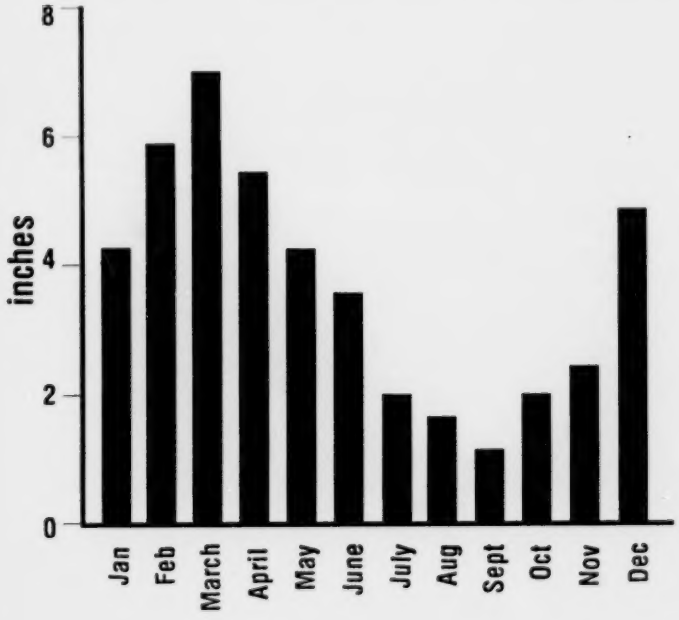
1. Look at the graph that shows the annual rainfall by month in the Chesapeake region. What months is the salinity of the Chesapeake Bay likely to be lowest? What time of year is it likely to be highest?

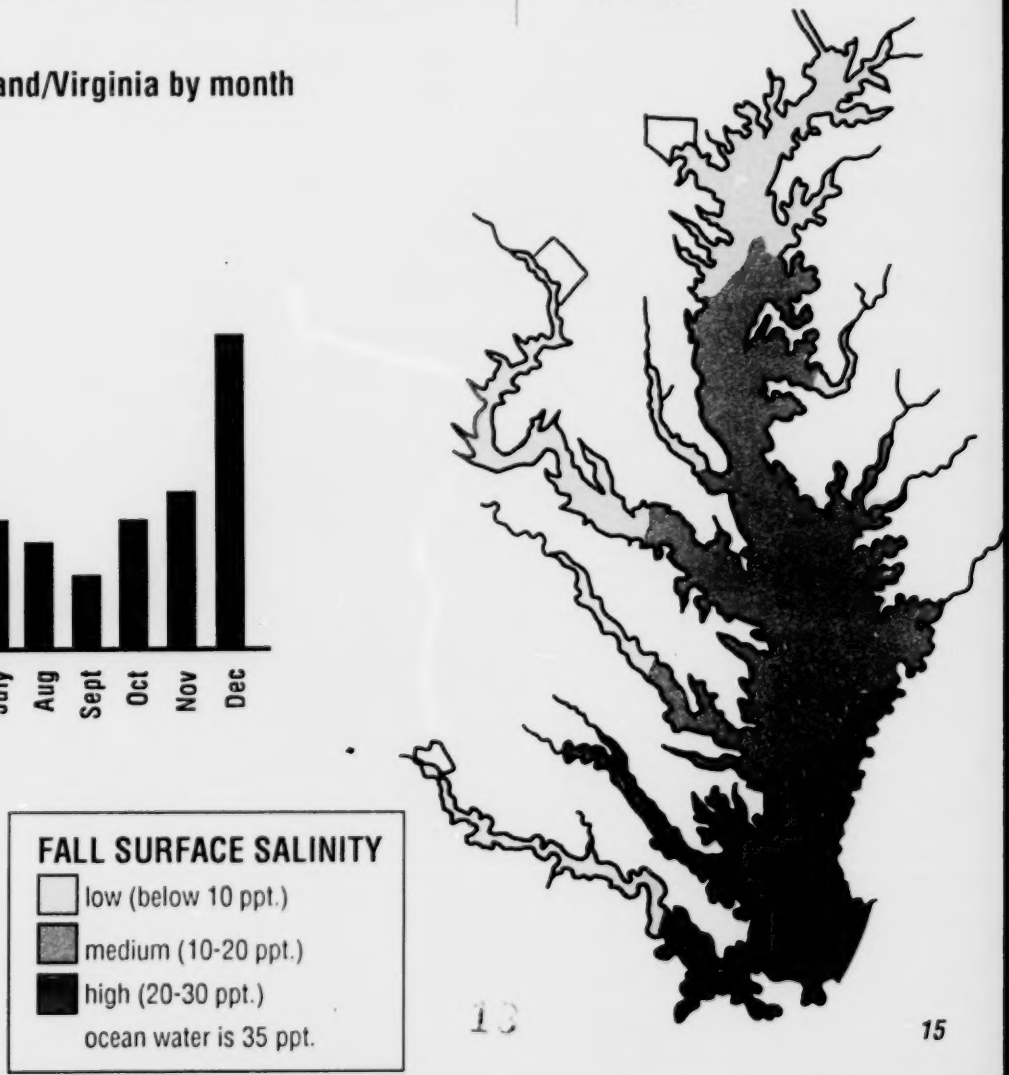
2. On the map on pages 30 and 31 color the area of lowest salt yellow, somewhat salty green and most salty blue.

3. Arrange these in order from saltiest water to least salty water:

- water from the surface of the Bay at its mouth
- water from the surface of the Bay at the Susquehanna River
- water from the surface at the middle of the Chesapeake Bay
- water from the bottom of the Bay at its mouth

Average Rainfall in Maryland/Virginia by month





Chesapeake Challenge

1. There are many estuaries in the United States. The Chesapeake Bay is the largest. Use a map of the United States to locate and list three other places that you predict are estuaries based on what you have learned about the characteristics of an estuary.

Family Action

1. At dinner list all the things you can think of that you eat that come from the Chesapeake Bay.

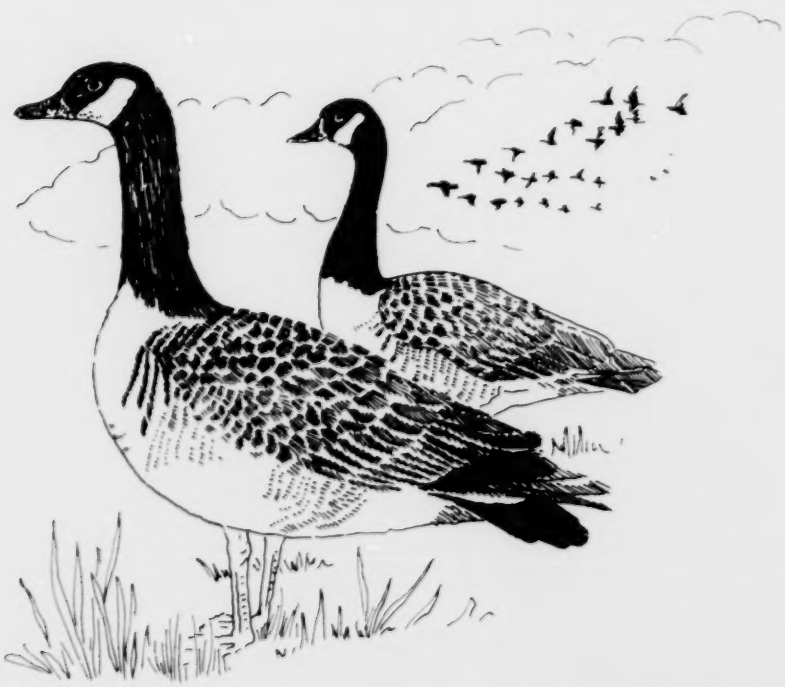
What is Special About an Estuary?

Estuaries have very high levels of plant nutrients because they are almost enclosed by land. Freshwater runoff carries these nutrients from the land. Any body of water with high levels of plant nutrients has high numbers of plants and algae. Since plants serve as food for all the animals that live in the water, where there are lots of plants, there are many animals.

In part because of the large food supply, estuaries are particularly good places for many young animals to get their start. They are nurseries for many species of fish, shrimp and other animals that live in the ocean as adults. Fish like shad, herring and striped bass (rockfish) migrate from the ocean through the estuary and into rivers to spawn, or lay their eggs. The eggs develop into larval (baby) fish which move down into the estuary to feed and grow before leaving to live in the open sea.

Other kinds of animals migrate to the estuary from the ocean because of the good supply of food. An abundant fish called menhaden come for the phytoplankton (tiny algae in the water). Bluefish come to feed on menhaden. Waterfowl spend winters there and fly north in the spring to nest.

About half of the fish and other sea animals we eat depend on an estuary during some part of their life. When we damage an estuary, we not only hurt the plants and animals that live there. We also destroy part of our food supply.



Tides in the Chesapeake Bay

The force of gravity from the Moon and, to a lesser extent, the Sun causes the water in the oceans to bulge out in some places on Earth while it is lower in others. If you stay in one place, the water level along the shore appears to rise and fall. These changes in water level are called tides.

The tides in the Chesapeake Bay are complicated by the fact that the bulge enters at the mouth of the Bay from the ocean and moves up the Bay. Before it reaches the top of the Bay, a trough of low water is already following it up the Bay. Each 24.8 hours the water at a point in the Bay rises and falls twice. The difference between high and low tide is about 2.5 feet at the mouth of the Bay in Virginia. It is only 1 to 2 feet in Maryland.

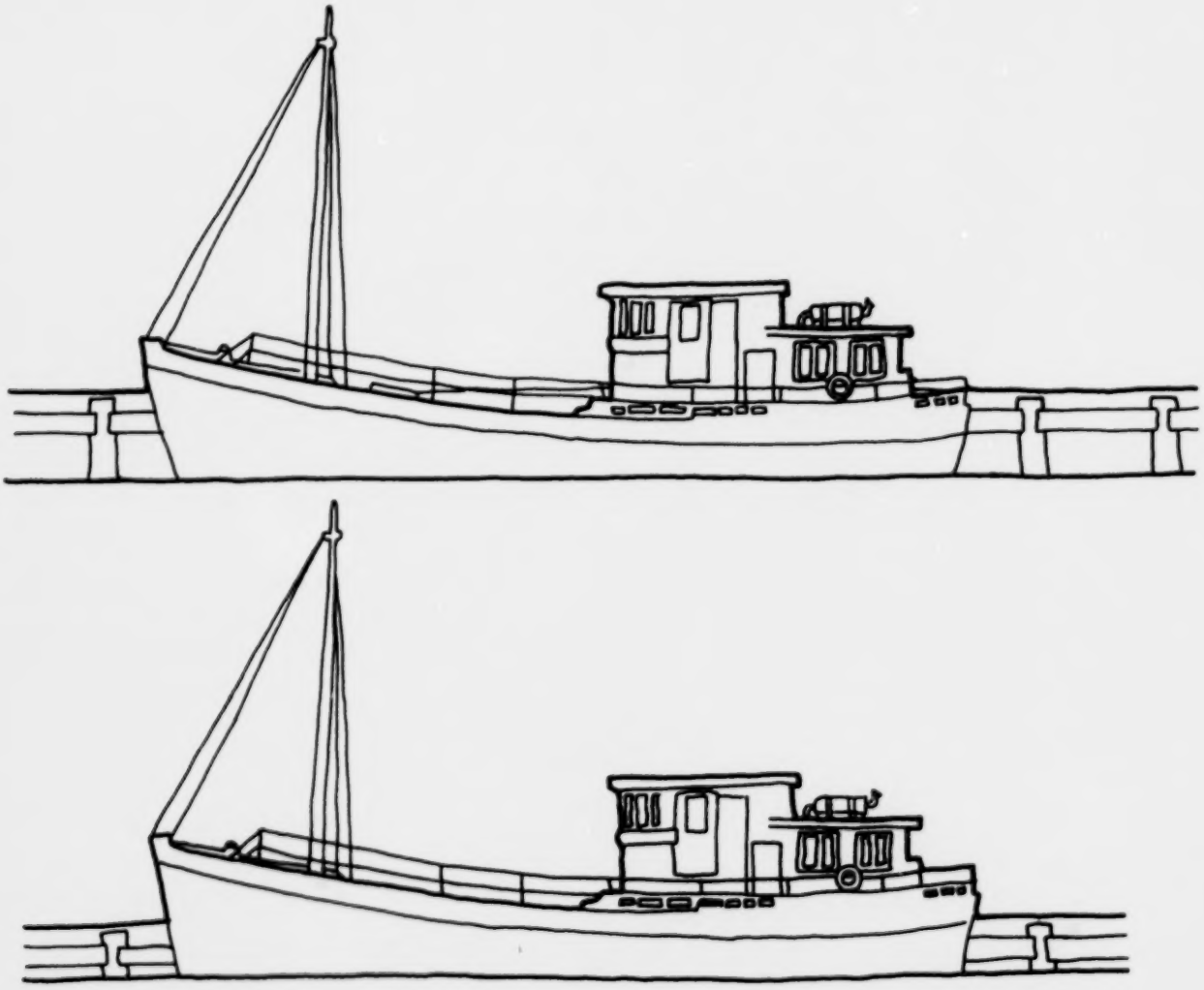
The water in the rivers of the Chesapeake Bay also rises during particularly heavy rains. When a strong wind blows up the Bay from the south, water tends to "pile up" at the top of the Bay. The combination of a heavy rainstorm with winds from the south and a high tide causes flooding in cities such as Baltimore on rivers near the Bay.

Chesapeake Challenge

1. Locate the tide chart in a newspaper. Check the sports section. Pick two locations on the Bay. Estimate how far apart they are with your state map. Use the tide chart to calculate how fast a low or high tide travels up the Bay.

Family Action

1. On a family trip to the edge of the Chesapeake Bay such as a trip to a park or Baltimore's Harborplace, note the level of the water at the time you arrive. Check changes during the day. Record your impressions of height and time.



Chesapeake Challenge

1. List two habitats found in shallow water.

2. List two habitats where tides are important.

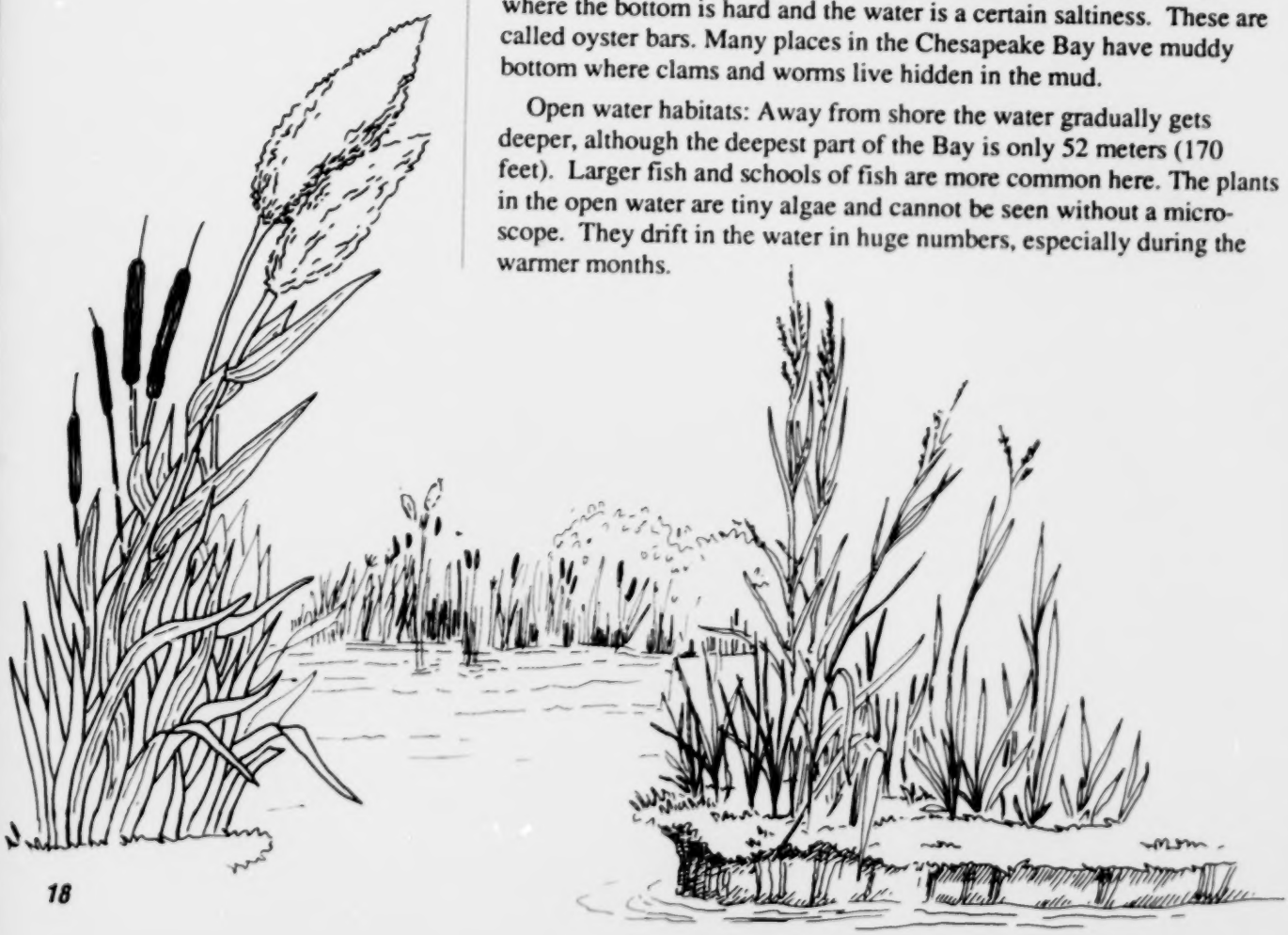
Chesapeake Habitats

The Chesapeake Bay probably did not change very much after the sea level stopped rising rapidly about 3,000 years ago. A variety of kinds of habitats (or places to live) existed then and still do. These are the kinds of habitats still found in the Chesapeake Bay.

Shoreline habitats: Tides affect the habitats along the shores of the Chesapeake Bay. Sometimes they are covered by water and other times they are uncovered. Where waves disturb the shore, sandy beaches form. Where the water is calmer, the bottom is muddy. Large grasses grow in many muddy places along the shore where the tide moves in and out. These form habitats we call marshes, which may cover a very large area. The saltiness of the water in marshes varies, depending on where the marsh is located. Some are even freshwater marshes.

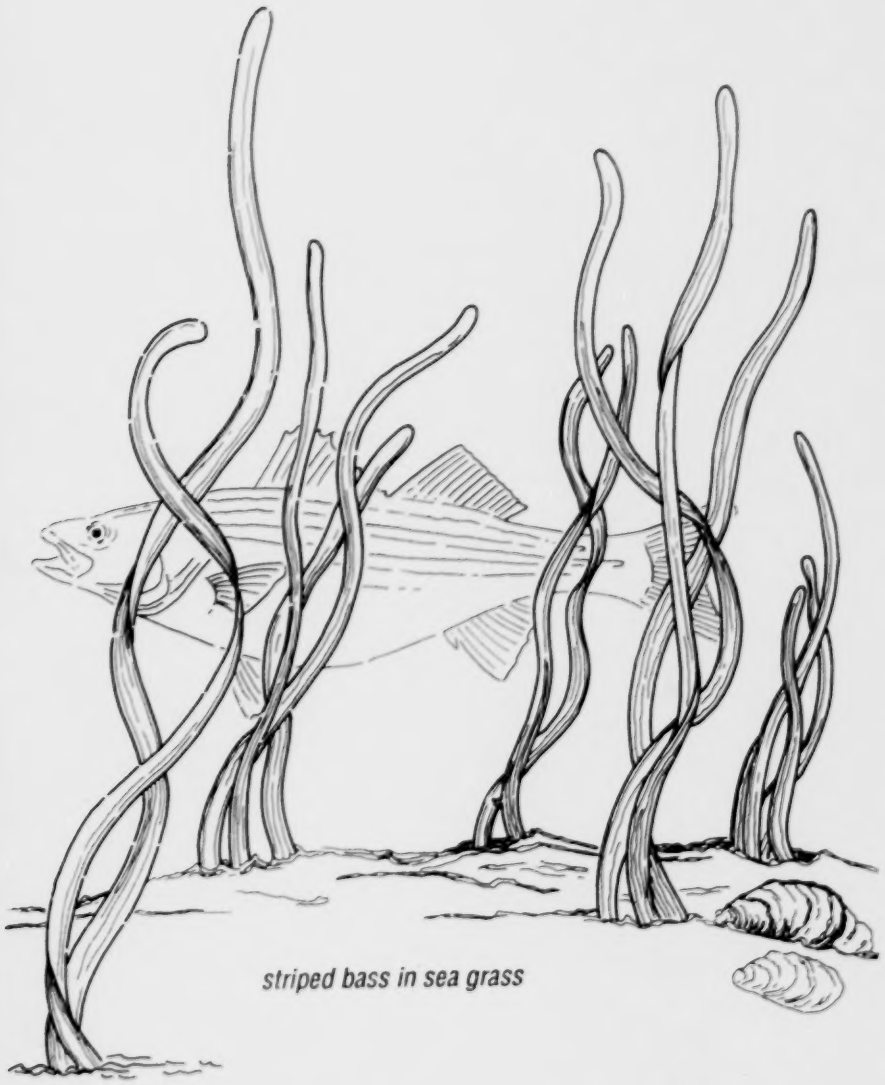
Shallow water habitats: Other kinds of plants grow in the shallow water just off shore. There are many different kinds of plants that grow underwater. The areas where they grow are called grass beds even though they are not really grasses. Another name for these plants is submerged aquatic vegetation. (If you check a dictionary, you will find that it is just a fancy way of saying underwater plants.) The kinds of plants in an area depend on how salty the water is in that spot. Some kinds of animals also like shallow water such as oysters which live where the bottom is hard and the water is a certain saltiness. These are called oyster bars. Many places in the Chesapeake Bay have muddy bottom where clams and worms live hidden in the mud.

Open water habitats: Away from shore the water gradually gets deeper, although the deepest part of the Bay is only 52 meters (170 feet). Larger fish and schools of fish are more common here. The plants in the open water are tiny algae and cannot be seen without a microscope. They drift in the water in huge numbers, especially during the warmer months.



Classifying Habitats of the Chesapeake Bay

Classification is a process in which things are grouped with other things that are similar. Here we start with one big group: the natural kinds of habitats in the Chesapeake Bay. This big group is divided into smaller groups which have things in common. Classifying the different kinds of places to live or habitats in the Chesapeake Bay is not easy because of the differences in saltiness from place to place.



striped bass in sea grass

Chesapeake Challenge

1. Use the Chesapeake Bay Habitat Cards on pages 21 and 22. If this is your own book, you might want to cut them out. If you are using this in class, your teacher will give you the cards. Read each card carefully and then use the classification system, or key, on page 20 to identify each habitat. Start with the two choices on the left. Pick the one that matches the card and go to the next pair of choices. Soon you will arrive at the name of your habitat. Can you get all eleven? Check your answers in the back of this book.

1_____

2_____

3_____

4_____

5_____

6_____

7_____

8_____

9_____

10_____

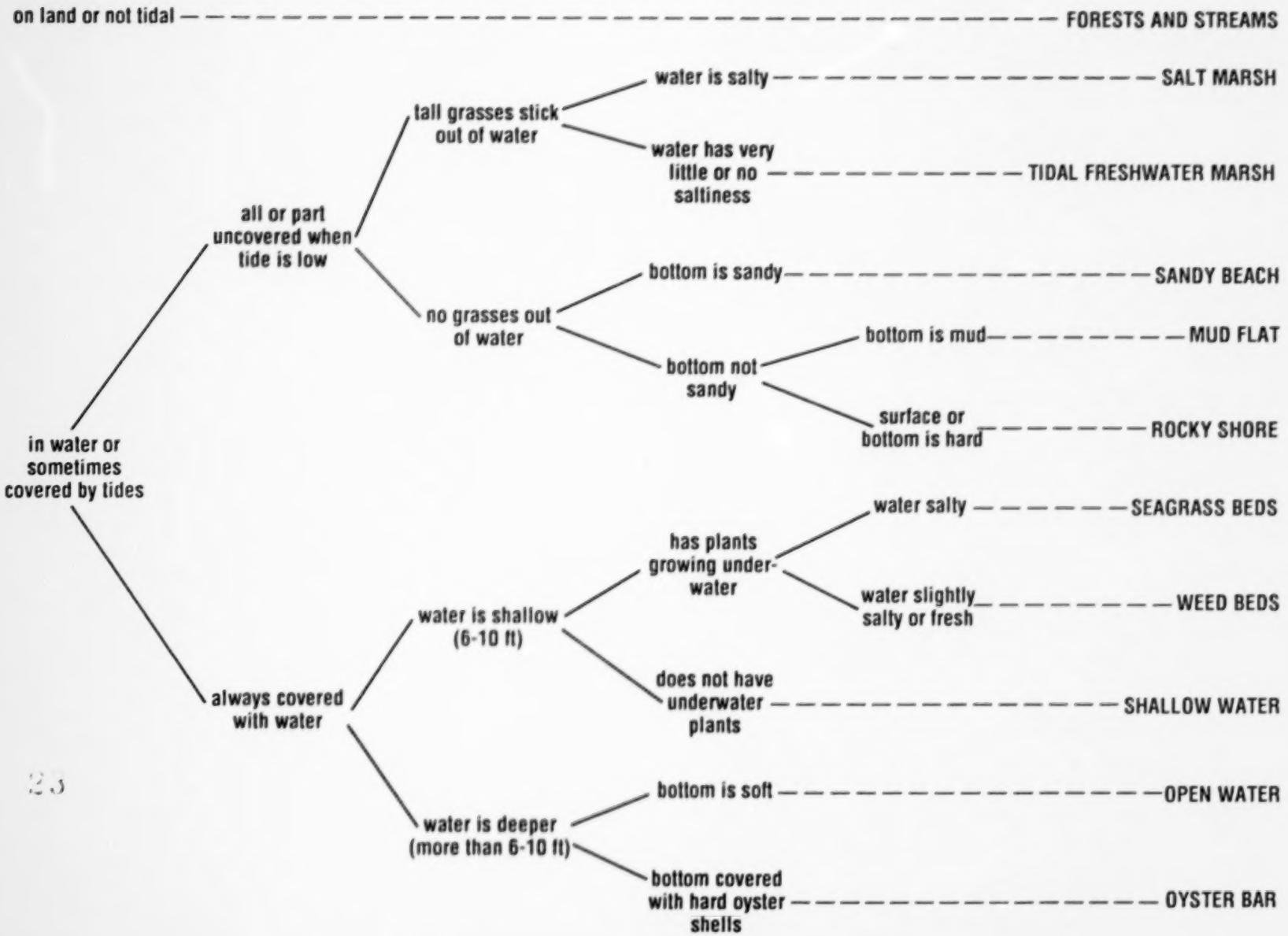
11_____

2. Pick one of these Chesapeake Bay habitats and research it using books like ***Life in the Chesapeake*** by Alice J. and Robert L. Lippson. Write one page about the kinds of plants and animals you might find there.

3. Using your research, draw a picture of the habitat, showing the plants and animals. Write their names on the back of the picture.

4. Write a travel ad encouraging people to visit the habitat you chose and illustrate it.

Key to the Habitats of the Chesapeake Bay

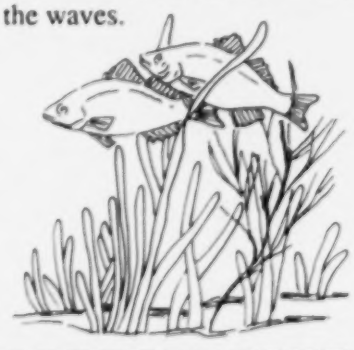


Chesapeake Bay Habitats

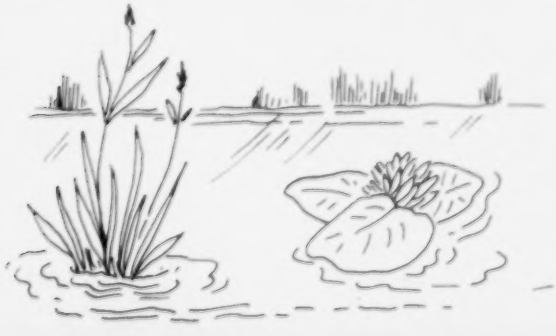
1. Where rocks are in shallow water along the shore, they may be uncovered by the tide. Manmade things like piers also have animals and plants that need hard surfaces as places to attach. Where the water is salty, some seaweeds grow.

2. Things living in shallow water are not uncovered by the tides, but must be able to stand heat and cold, wind and waves which make the water muddy, and even ice in winter. But small fish are safer from the bigger fish that eat them here, and there is lots of food. There may be marshes and grass beds nearby which are places to hide if needed.

3. In the lower part of the Bay where the water is saltier, two kinds of plants may grow under the shallow water. They can only live where it is shallow because they are rooted on the bottom and need light to make food. The plants are eaten by many animals and many more find a safe place to live among the plants. These plants protect the shore and reduce the muddiness of the water by slowing the waves.



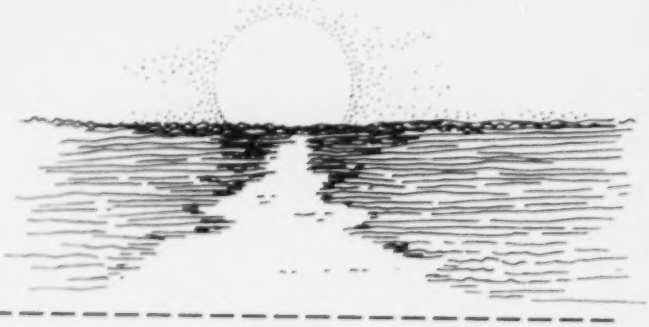
4. Tall grasses grow up out of the water. Even though the water has little or no salt, the tides push up the Bay or rivers far enough to cause the water level to change here. Other plants like pond lilies also grow here. The plants provide food for many kinds of invertebrates and fish which also hide among their stems.



5. Fine bits of dirt make mud when they settle out of the water. Where the muddy bottom is very shallow, it is uncovered at low tide. While this area may not look like home to many animals, there are lots of creatures living down in the mud. Watch for shorebirds searching in the mud for some of them.

6. In some places where the saltiness is right and there are dead oyster shells, oysters and many other animals live. The water is deep enough to protect the animals from being uncovered by the tides or disturbed by hard waves.

7. In deep water little light reaches the bottom. Since plants need light, they do not grow here. The water is filled with tiny, drifting algae which use the sunlight near the surface to make food. The bottom is covered with mud which has settled from the water. In this open space large schools of fish swim together.



8. The waves during storms push the grains of sand in ever-changing patterns. During low tide the animals that live among the sand grains feel the summer heat or the winter cold. Shorebirds search along the water's edge for these animals and for bits of food that wash in from the Bay.

9. In shallow water where there is good light and the water has little salt, underwater plants sometimes grow. Some of these plants are valuable as food for many kinds of waterfowl such as ducks, geese and swans. All make places for little fish and other animals to live and feed. These plants also slow water movement and protect the shore from waves.

10. Along the shore where the water is salty, tall grasses grow out of the water. Tides move in and out, but some places are flooded only during storms and very high tides. These tough plants break down in the water to form little bits of food called detritus which many animals eat by filtering it out of the water.

11. Trees cover the land. Water runs among the trees. Sometimes the trees grow where there is very slowly flowing fresh water around them.

Chesapeake Bay Food Chains

Bay plants grow rooted to the bottom. Some are marsh grasses. Others are underwater plants like seagrass, pondweed and seaweed. There are also many kinds of tiny algae which drift in the water with tides and currents. They are called phytoplankton, which means wandering plants. To grow they all need energy from sunlight and mineral nutrients from the soil or the water. These nutrients are chemicals that contain nitrogen or phosphorus. When there is not much sunlight or nutrients, plants and tiny algae grow slowly. If there is lots of light and nutrients, the plants grow fast.

Many Bay animals depend directly on these plants for food. The algae are filtered out of the water by clams, oysters and a fish called menhaden. The marsh grass is tough, but it is eaten by bacteria when it dies. They break the grass into small bits called detritus which are eaten by many animals. The underwater plants are softer. They are eaten by ducks and geese, and even deer and muskrats. Some animals like snails eat different kinds of algae that grow on the surface of mud or marsh grasses.

Many small animals feed on algae and detritus. Some like worms and barnacles live in the bottom or attached to surfaces. Others animals drift through the water, like the drifting algae. Because they are animals, they are called zooplankton (zoo means animal). The small zooplankton may be eaten by larger zooplankton like the jellyfish called sting nettles or they may be eaten by small fish. The small fish become dinner for larger fish or birds.

Different kinds of fish and birds specialize in eating the animals that live on or in the bottom. Blue crabs live on the bottom and eat most anything from detritus to other animals. One kind of turtle that lives in the salty part of the Bay, the diamondback terrapin, eats snails and other animals. Even raccoons eat many kinds of Bay animals which they catch at low tide.

Chesapeake Challenge

1. The relationship of who eats whom is called a food chain (or food web). Place the following groups of animals in the correct sequence with the food producer (plant) first:

a. diamondback terrapin, algae on mud, snail

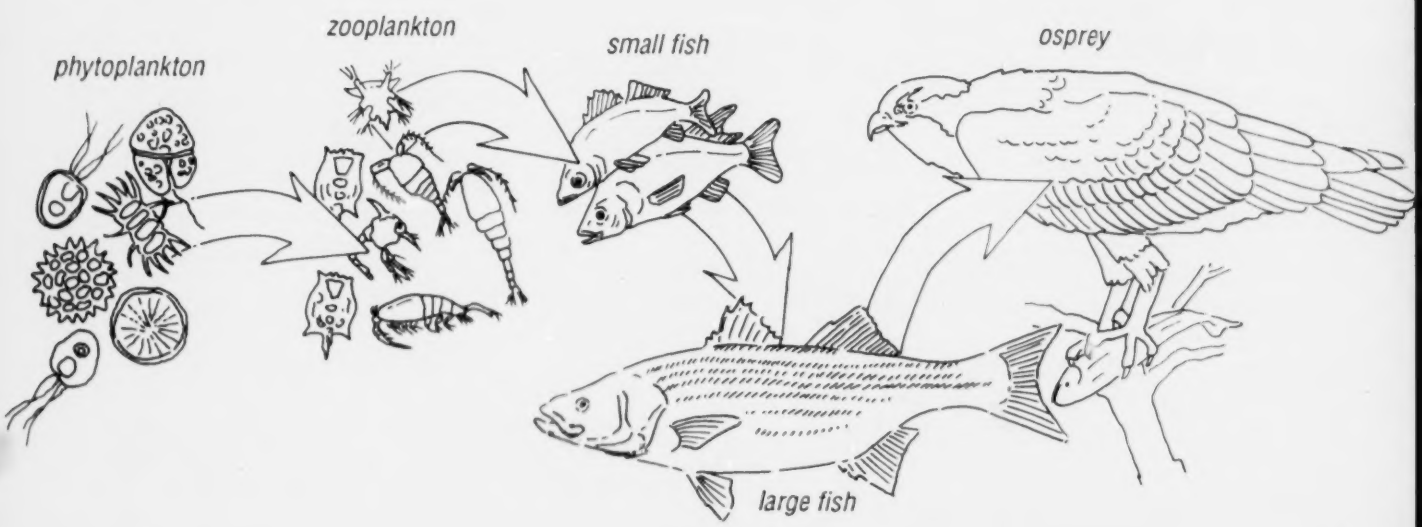
b. zooplankton, small fish, large fish, large fish-eating bird (osprey), phytoplankton

2. Group these together into three pairs based on their place in the food chain: bottom, middle or top.

small fish, larger fish, phytoplankton, fish-eating birds, underwater plants, zooplankton

Family Action

1. Take a look at your dinner tonight. Where would you fit in the food chain? What other animals might eat the kinds of food on your plate?



Chesapeake Challenges

1. How big are they really? The pictures of Chesapeake Bay zooplankton on this page tell you how much bigger the drawing is than the animals are in real life (100x means the picture is 100 times bigger than the real animal.) Use a metric ruler to measure each drawing in millimeters (mm). Then divide by the number of times the drawing was enlarged to find its the real size.

2. Order the kinds of zooplankton shown on this page from smallest to largest.

3. Pick one of the zooplankton on this page and imagine what life would be like at that size, drifting with the water currents, eating and being eaten. Write a paragraph about how it would feel.

4. With your teacher's help, you can see real zooplankton. Ask if she/he can bring some to class. (See Teacher/ Parent section.)

Zooplankton in the Chesapeake Bay

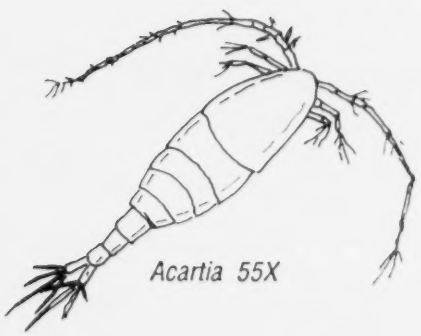
The term zooplankton means wandering (or drifting) animals. They cannot swim strongly enough to go against currents or tides. Many people think that all zooplankton are tiny animals that can only be seen with a microscope. Some are too small to see with your eyes, but many others are much larger. For example, jellyfish are zooplankton. There are thousands of kinds of animals that are zooplankton for all or part of their lives.

Some zooplankton feed on phytoplankton which is present in large amounts in the Chesapeake Bay. Some even feed on tiny bacteria which are also common in Bay water. Different kinds of phytoplankton in different seasons cause some zooplankton to be more successful than others. Larger zooplankton and small fish feed on smaller zooplankton. Zooplankton form several links in the food chain.

Some animals, such as copepods, are zooplankton all their lives. Other animals drift for only part of their lives and spend the rest swimming or on the bottom. Crabs and oysters drift as eggs and larvae (babies), but change as they grow. Blue crabs crawl from place to place or swim, while oysters settle in one place forever. The eggs and larvae of many of Chesapeake Bay fish are zooplankton until the young fish grow large enough to swim against the currents.

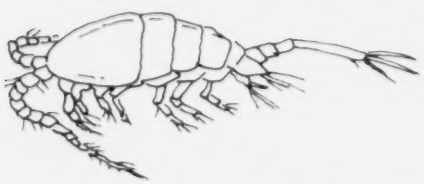
Some zooplankton drift all the time, but others hide in or on the bottom some of the time and go up in the water to feed at others. Time of day and tides are both important to these zooplankton.

The amounts and kinds of zooplankton in the Chesapeake Bay are important because most fish depend on them for food at some point. Striped bass larvae need the correct zooplankton to eat. No correct zooplankton, no striped bass.



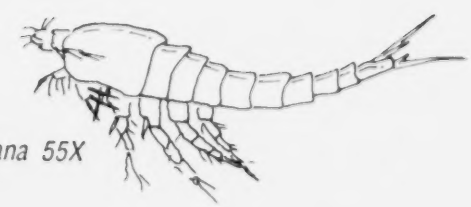
Acartia 55X

Eurytemora 55X

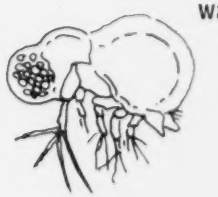


copepods

water flea



Scottolana 55X



Podon 65X

Blue Crabs in the Chesapeake Bay

Blue crabs live in estuaries all along the Atlantic and Gulf coasts, but they are most often associated with Maryland where they are very popular cooked in hot spices. About 1 million bushels are caught for food each year. These crabs have swimming paddles on their fifth pair of legs which help them really get around. At one time or another blue crabs can be found almost everywhere in the Bay.

Like all crustaceans, blue crabs shed their old, hard shell, expand and grow a new one in order to grow larger. This is called molting. A crab that has just molted is soft and helpless. These soft shell crabs hide in underwater plants to avoid being eaten by fish or other crabs until their new shell hardens. On the other hand, a hard shelled blue crab is anything but defenseless. It uses its two claws to defend itself and to eat clams, oysters, dead fish and plants.

Male blue crabs stay in water of lower saltiness in rivers and toward the top of the Bay. In winter the males migrate to deeper water, but during the rest of the year they spread out into shallow water. The females live in saltier water. From June to October males search for females ready for their last molt and mate with them when they are soft shelled crabs.

Each female makes 1-2 million eggs! The fertilized eggs are carried under her body where they develop as she migrates toward the mouth of the Bay during the summer and late fall. There the eggs hatch, releasing tiny babies (larvae) called zoeae which become part of the zooplankton. They may even drift out into the ocean before being carried back into the Bay by currents. They feed, molt and grow into another form called megalopae which settle to the bottom. As megalopae, they continue to feed, grow, molt, and move with the bottom currents up the Bay. They gradually begin to look like adult blue crabs. Crabs take from 12-20 months to become adults and only live about 3 years.

Chesapeake Challenge

1. Mark the path that female crabs take in the Bay each year on the map on page 26. Calculate the distance a female travels from the Patapsco River in the upper Bay. From the Rappahannock River.

Family Action

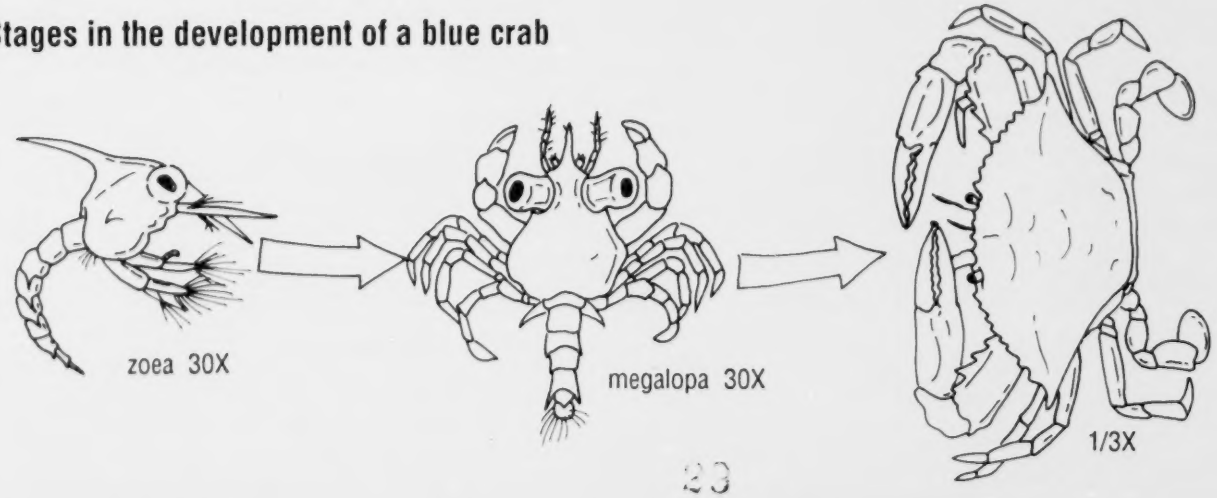
1. Visit a seafood market where blue crabs are sold. Find out where the crabs were caught. During the winter you may not be able to find crabs. In the spring, you might be surprised by where they come from.

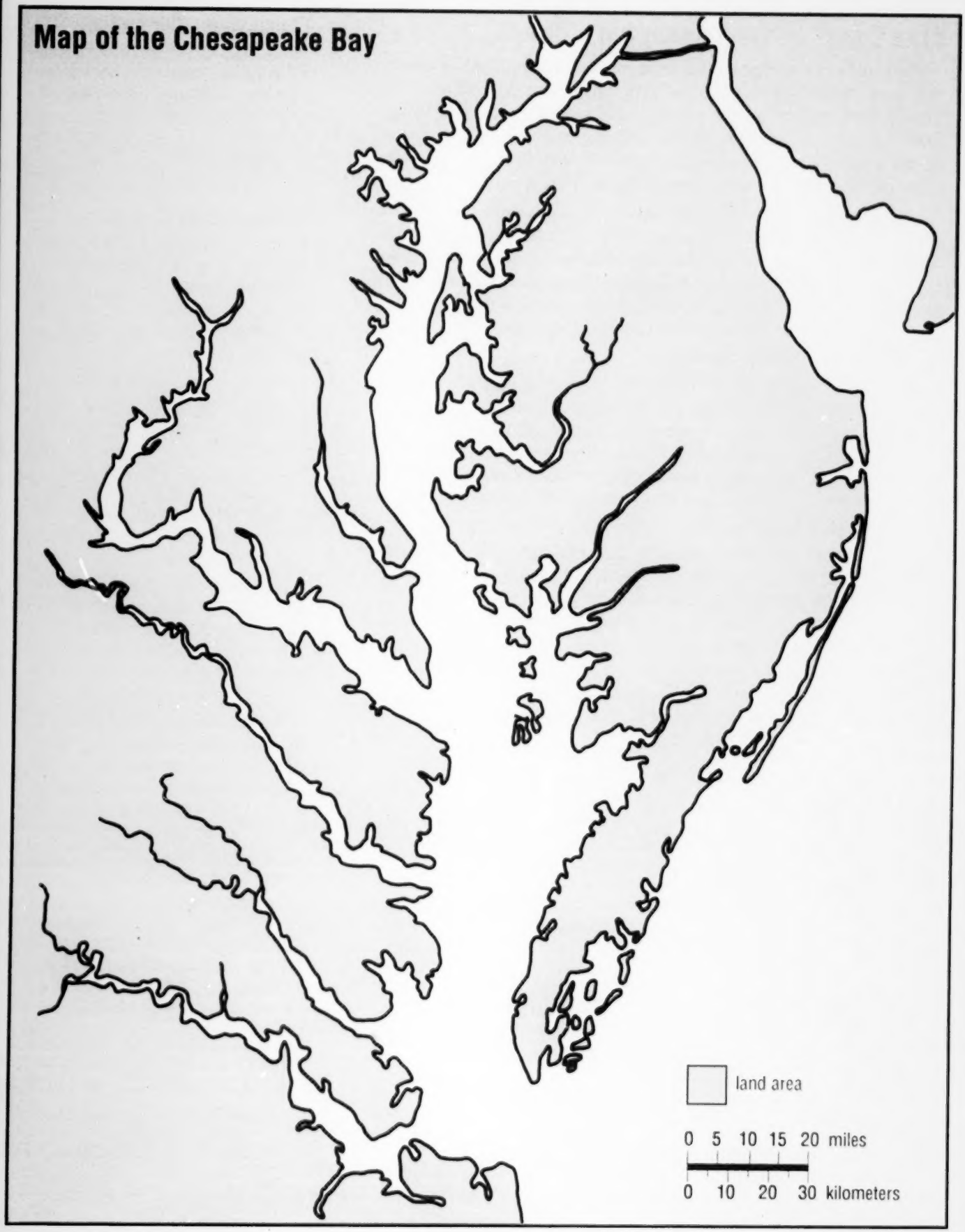
2. Rescue a live blue crab from the market and keep it in a brackish water aquarium. Observe its behavior, including feeding, swimming and defense. Does the crab have good vision? Can it sense food in the water? Put a drop of food coloring in the water near the back end of the crab. Where does the water go?

3. Eat a cooked blue crab. Examine its eyes, legs and shell carefully before opening it. List at least three ways you observe that a blue crab defends itself against predators. (Hint: they are not red until they are cooked.)

4. Visit the Maryland Science Center's Chesapeake Bay exhibit. You will find a giant blue crab that welcomes you at the exhibit entrance. Other places you can see live blue crabs on display include the National Aquarium in Baltimore and the Virginia Marine Science Museum in Virginia Beach, VA.

Stages in the development of a blue crab




Map of the Chesapeake Bay
land area
0 5 10 15 20 miles
0 10 20 30 kilometers

Oysters

Oysters are related to clams and mussels. They have two rough, heavy shells which they add to as their soft bodies grow. They need to live on a firm bottom so that they do not get buried in mud. Male and female oysters release eggs and sperm to the water. The eggs become drifting larvae which must find a place to settle as they grow. They grow into baby oysters, called spat, which settle on the bottom, generally on old oyster shells. Oysters make millions of eggs, but only a few survive to become adults.

Oysters make a living filtering phytoplankton (tiny algae) from the water. They also trap tiny bits of dirt in the water which are the same size as the algae. They make pellets of their waste products and the dirt which they deposit on the bottom. Hence, oysters clean the water by removing both algae and bits of dirt.

A Maryland biologist, Roger Newell, thinks that some of the changes in the Chesapeake Bay in the last 100 years might be caused by the overharvesting of oysters. As the graph shows, oyster harvests increased until about 1880 and then dropped. They went down because so many oysters were taken that there were not enough left to produce new oysters. The Bay's oysters have also suffered from diseases and snails called oyster drills which eat them. Dr. Newell thinks that as the oysters disappeared, the amount of phytoplankton increased because the oysters were not eating it.

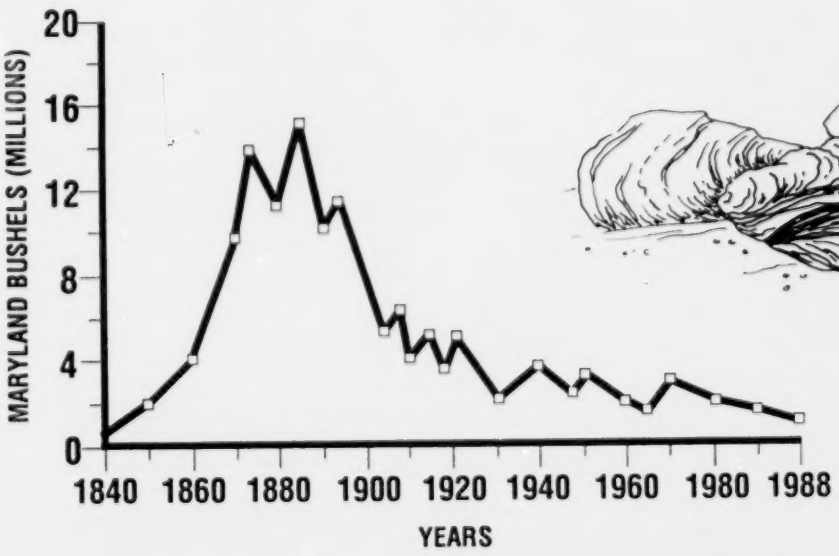
Dr. Newell calculated that the oysters in the Bay in 1880 were filtering all the water in the Bay every 1.5-3 days. One thing we might do today to reduce the algae and tiny bits of dirt in the Bay's water is to protect and increase oysters. We do know that there are too many phytoplankton and too much dirt in the water and that oysters would help filter these out.

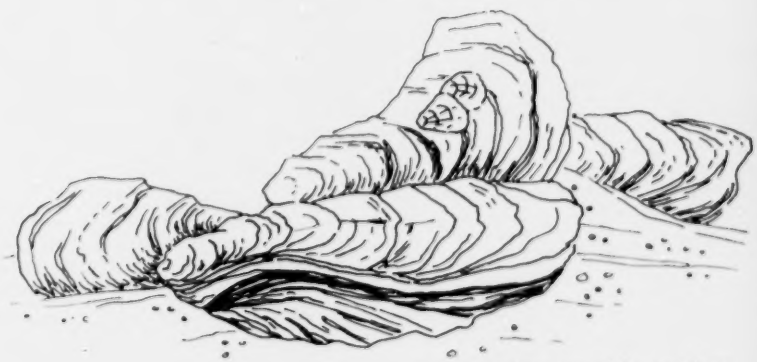
Chesapeake Challenge

1. Research the biology of oysters and design a plan to increase the number of oysters in the Chesapeake Bay.

2. Read the graph of the number of bushels of oysters taken in Maryland. About how many million bushels did they get in 1880? 1920? 1980?

3. Draw a Bay food chain with oysters present. Predict which groups of animals would benefit if oysters were removed.





young oysters on older oysters

Chesapeake Challenge

1. Name another kind of animal discussed in this booklet which filters phytoplankton from the water.

2. Mark annual path of menhaden into and out of the Bay on the map on page 26, using a new color. They even swim into low salinity areas like Baltimore Harbor. Label it.

Family Action

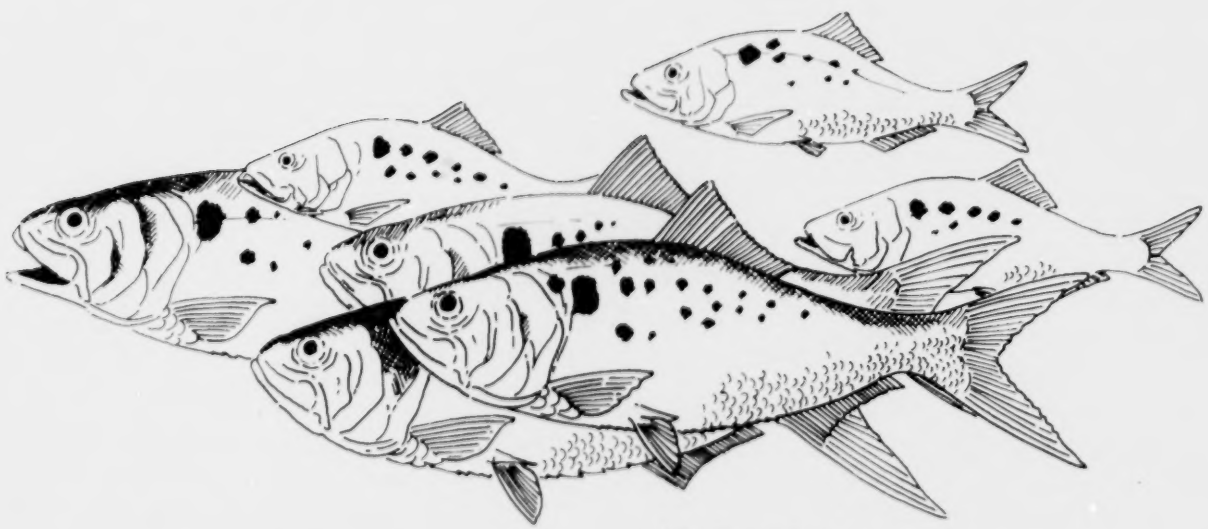
1. Do you use menhaden in your home? Examine the labels of pet food bags to see if your pets are eating fish meal. If you have oil-based paints, check their labels too. If you eat eggs or chicken, you have eaten animals that were fed fish meal.

Atlantic Menhaden

Menhaden are fish related to herring and shad, but they do not migrate into the Bay to lay their eggs. They spawn in the ocean. The young menhaden come into the Bay on currents to feed on phytoplankton. Very few other fish are able to filter these tiny algae from the water. Menhaden feed by swimming with their scooplike mouths open. The tiny phytoplankton are caught on fine combs on their gills as the water flows past the gills and out the sides of their heads. Animals that eat plants or algae are said to feed low on the food chain. Because the Bay is so rich in algae, menhaden have a huge amount of food that other fish cannot eat.

Menhaden swim in large groups called schools. Both the young and the adults live in the Bay. They are easy to catch in nets. They taste bad, but have many important uses. Menhaden, also called bunker, are used for crab bait in traps. They are very oily fish. They are processed to produce oil which is used in paint and other things. Their meat is made into fish meal which is used in feed for farm animals such as chickens and pigs and for pet food. When the price of soybeans (a plant rich in protein for animal feed) is high, menhaden are caught in huge numbers. Food scientists are experimenting with ways to make menhaden taste good enough for people to eat, because they are a very cheap source of protein.

Menhaden are also important as food for other animals in the Chesapeake Bay, especially bluefish. As the nutrient levels of the Bay have increased, the Bay has become an algae soup. Menhaden have done well, and so have the bluefish.



Atlantic menhaden

Striped Bass

Striped bass (also called rockfish in the Chesapeake region) are the most famous of the Bay fish. They are important both as sportfish and for commercial catch. There have always been some ups and downs in the number of rockfish. Currently, striped bass are in serious trouble.

Striped bass migrate up the Bay to almost fresh water to lay their eggs (spawn) in rivers each spring. The babies (larvae) feed on zooplankton and grow. As young fish, they move to saltier water to feed. Some Chesapeake Bay striped bass stay in the Bay, but others swim out into the ocean and up the coast as far as Nova Scotia. These fish return to the Bay to lay their eggs.

What has caused the low number of rockfish? There are a number of ideas. The problem is probably with spawning and the young fish. Acid rain is killing the eggs and larvae in some rivers. The middle Atlantic states have very acid rain. In other rivers toxic materials are killing the young. Some people also think that the zooplankton in the Bay have changed and are not right for the young fish to eat. There is one thing we do know. The size that is legal to catch and keep has been too small. Fishermen took the larger fish that are most successful as mothers. The bigger fish need protection as they are the best at making good eggs. Some state laws have increased the legal size.

States around the Bay and up the coast need to cooperate for the rockfish to increase. There are still some large striped bass in the Bay so it is not too late if we can solve their problems.

Chesapeake Challenge

1. Use the map on page 30 to find Nova Scotia and estimate how far a striped bass swims from the Bay to get to Nova Scotia.

2. Fishing laws are made by each state. Striped bass are caught in most states between North Carolina and Nova Scotia. How many states and provinces would have to cooperate in making fishing laws to protect a fish that swims from the Bay to Canada?

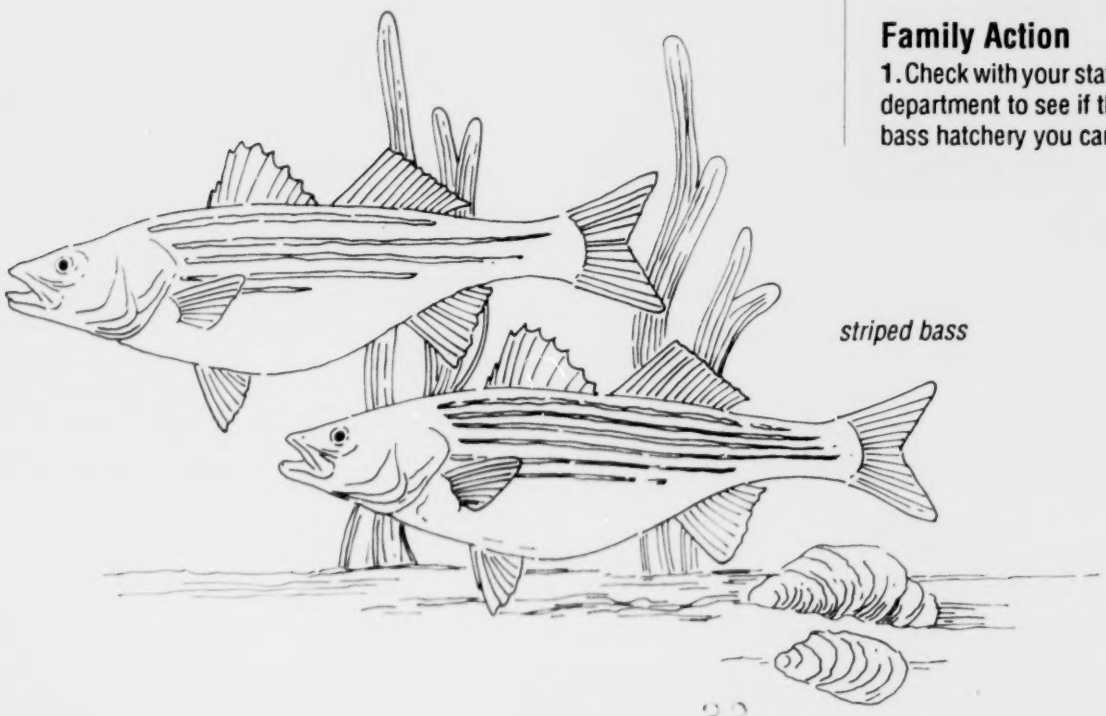
3. Test for acid rain with special paper. Your teacher may have some or it can be ordered from garden catalogs that sell soil testing materials. Use a glass jar to catch the rain. Test it, and record your results each time it rains. 7 means the rain is not acid. Lower numbers indicate acid conditions. Numbers lower than 5 are very acid rain. Remember March to June is the time for fish to spawn in the Bay.

4. Research acid rain in the library. List 3 things that cause acid rain. List 3 things that could be done to reduce it.

5. Mark the route of striped bass in the Bay on the map on page 26. Use a new color and label it.

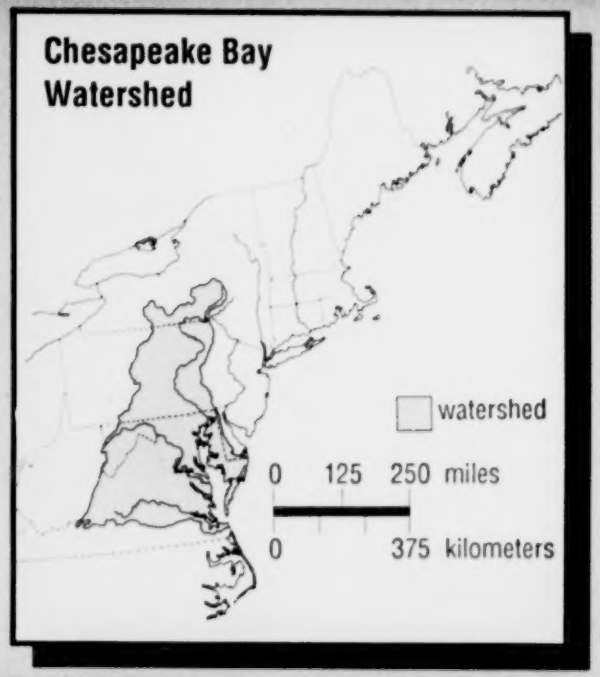
Family Action

1. Check with your state fish and game department to see if there is a striped bass hatchery you can visit.



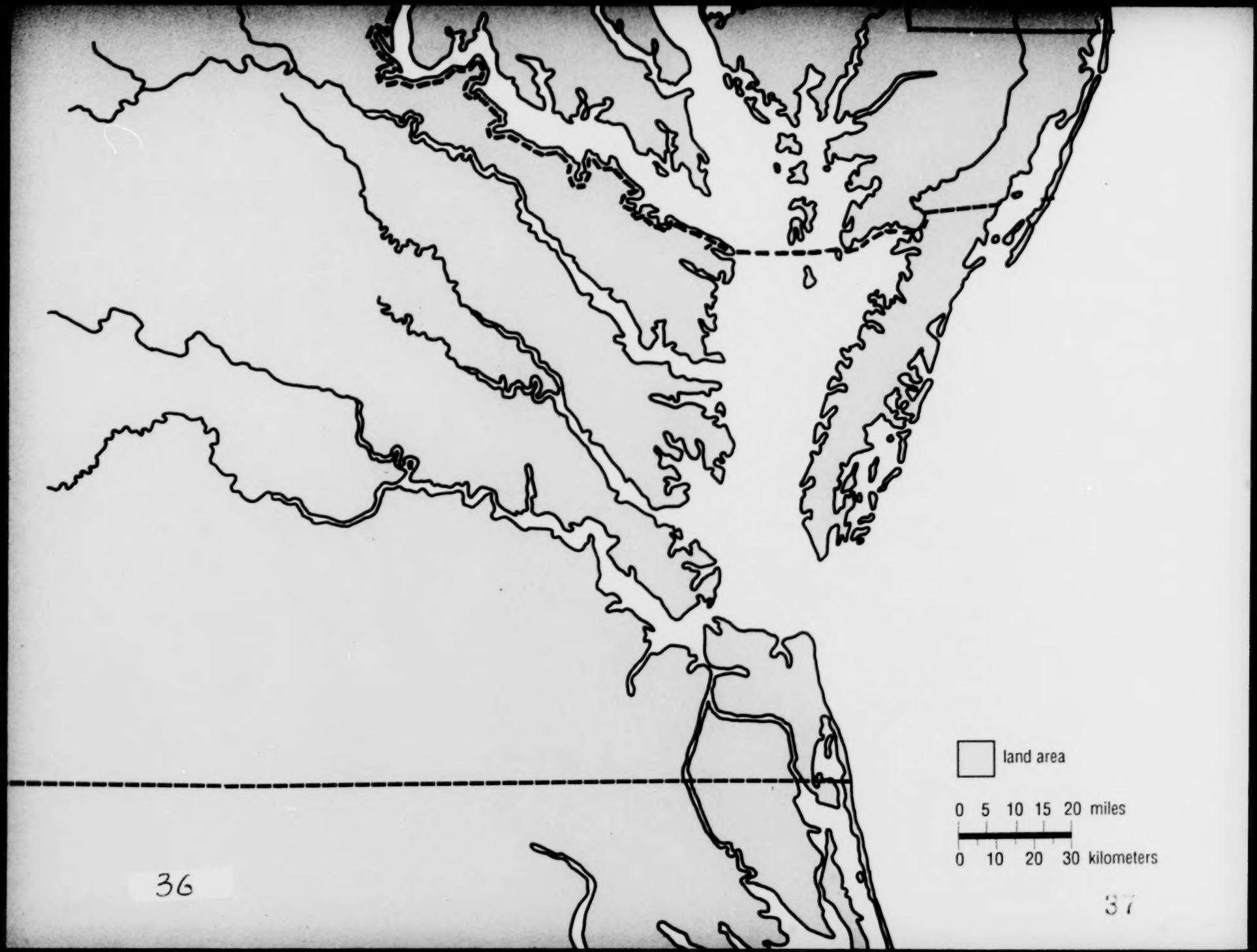
striped bass

The Chesapeake Bay and its Watershed



34

35


land area
0 5 10 15 20 miles
0 10 20 30 kilometers

Changes in the Chesapeake Bay and its Watershed Caused by European Settlement

European settlers caused enormous changes on the land around the Chesapeake Bay and in the Bay itself. These changes came about because of the way they used the land and the Bay. While the settlers grew in numbers and in wealth, they caused changes which continue to harm the Bay today.

European Settlement of the Chesapeake Bay

English people made their first permanent settlement in Virginia on what they called the James River in 1607. The sponsor of the colony was the London Company. Their goals were to find gold and other valuable materials and to find a sailing route to the Pacific Ocean, commonly called the Northwest Passage. They chose a point of land that was almost surrounded by water which would be easy to defend against the Native Americans who lived nearby and were not entirely happy about the new village. The land was low and swampy with mosquitoes that carried malaria and the sandy soil was not good for crops. They called the settlement James Towne (Jamestown) for the English king. Disease, hunger and conflict with the Indians caused misery and death among the early settlers.

After 1605 Catholics were persecuted in England. In spite of this, George Calvert, the first Lord Baltimore, converted to the Catholic religion. After an attempt to settle Newfoundland failed because of the cold, he became interested in the Virginia area where settlers had overcome early problems. In 1632 he got a warrant from the English king for the land from "the River Pattomack" to the Delaware Bay and the 40th parallel and westward to the "Pattomack" headwaters. He died but his son sent a group in two small ships, the ***Ark*** and the ***Dove***. They arrived in Maryland in spring of 1634.

The Maryland settlers learned from the Jamestown experience. They first met with the Indians, the Piscataways, and purchased a village from them. They got shelter and fields already planted with crops on a site with good water and a deep creek for their ships. They renamed the village St. Mary's City. They did have a "war" in April and May of 1635 with William Claibourne who had started a fur trading post on Kent Island in 1631. He traded with the Susquehannock Indians who came down from the north with furs. Claibourne refused to pay rent to the new colony.

Chesapeake Challenge

1. Locate the sites of Jamestown and St. Mary's City on the map on pages 30 and 31 and write in their names.

2. Compare each in terms of where they are in relation to the rest of the state. Why do you think both were later replaced as state capitols?

Family Action

1. Visit Jamestown or St. Mary's City. The original buildings have mostly been lost, but reconstructed buildings and ships give you an idea about life in these settlements. If you go during the winter when there are not many people, you can sit quietly in one of the ships and imagine how scary it must have been to cross the Atlantic Ocean in such a craft. The park at St. Mary's City includes a reconstruction of an Indian dwelling as well.

Chesapeake Challenge

1. Graph the rate at which tobacco sales from the Virginia colony grew.

2. Tobacco was packed for shipping in huge barrels called hogsheads. These were often gotten to port by being rolled, pulled by oxen or horses. The roads used were called rolling roads. Have you ever seen a local road called Rolling Road? Using the index, try to locate roads with this name on a local map.

Family Action

1. Visit a living history farm where tobacco and other early crops are grown in much the same way that the early colonists did: the National Colonial Farm in Accokeek, MD south of Washington, DC.

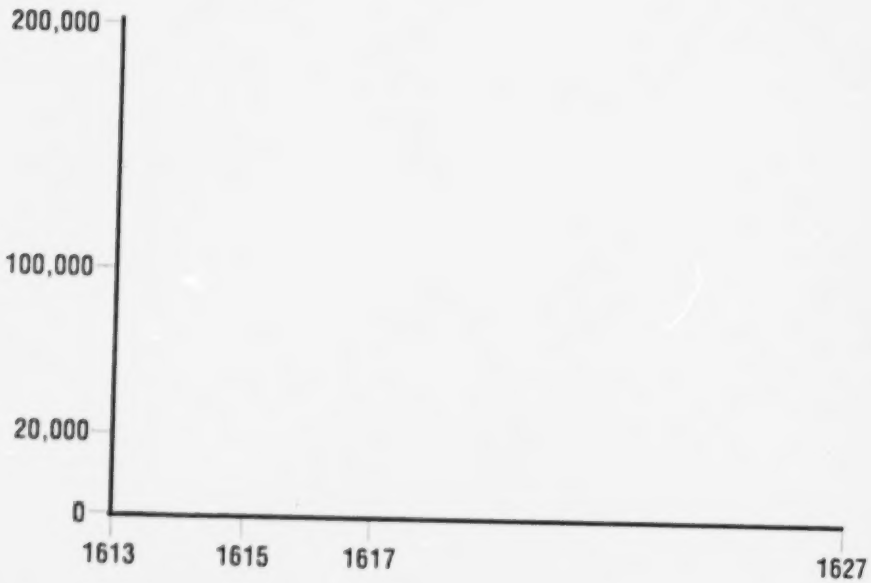
Growing Tobacco

Jamestown might have been abandoned if John Rolfe had not started growing tobacco in 1612. The Indians grew and smoked a rough, native tobacco. Rolfe imported better quality tobacco seeds from the Caribbean and experimented with growing it. Tobacco was profitable for the new colonies. The first crop was shipped to England in 1613. In 1615 2,300 lbs were sent to England. By 1617, 20,000 lbs were shipped. Ten years later, 200,000 lbs were sent to England.

Tobacco requires many people to plant, weed and harvest it. It is a labor-intensive crop. Initially, the work of raising tobacco was done by indentured servants, people who paid for their trip to the colony by agreeing to work for a set number of years for free. At the end of that period, often 5-7 years, they were given land, food and tools. A Dutch pirate left 20 blacks he had captured in the West Indies in Jamestown, the start of slavery. Slaves eventually replaced indentured servants as the labor force used to raise tobacco. Early in the colony, land owners, servants and slaves lived, worked and ate together, according to archaeologists who study old sites. Later, as farms grew into plantations and landowners became wealthy, slaves lived and ate in separate quarters.

Tobacco uses up the nutrients in the soil very rapidly. It is said to "wear the soil out." New land was continuously cleared of trees to replace the worn out fields. As tobacco growing spread, the forest disappeared. When the land was used up, it was abandoned. Frances Trollope travelled between Washington, DC and Richmond, Virginia in 1830. He described the trip through a wasteland of abandoned, eroded fields. Even today when driving on Interstate 95 between Richmond and Washington, you can see how only stunted trees grow in much of this area.

Tobacco is still grown is southern Maryland. You may see it if you travel along country roads there in summer. In Maryland on Route 301 you pass tobacco storage and auction houses in several locations, including a very large one in Upper Marlboro.



The Force of Moving Water

The force of moving water is very powerful. Moving water has the power to pick up and carry soil particles in a process called erosion. Tides and waves can erode shorelines. The faster water moves, the larger are the particles it can carry. During floods, rivers can move boulders. When water stands still, particles of soil settle out.

Rain and melting snow pick up bits of dirt and carry them into streams and rivers. In streams where the water runs rapidly, these particles stay in the water. Where streams enter slower moving rivers, the sand and gravel and larger bits of soil settle to the bottom. When rivers enter the Bay, the water slows even more and more of the particles settle out. The movement of the Bay due to tides, wind and currents keeps some of these particles in the water, making it look muddy.

Erosion increases with greater rainfall such as a big storm and when the water runs over steep slopes. It is also much greater when there are no plants growing in the soil to hold it in place. When Captain John Smith wrote about the Chesapeake Bay region, he said that the watershed was covered with forests. The early European settlers cleared the forest for fields and for logs to build homes. Forests were also cut for fuel. Soil, especially from farms, eroded from the land and washed into rivers and the Bay, filling in the shoreline. Upper Marlboro was a tobacco shipping port in the early days of Maryland. Now it is eight miles upstream from water deep enough for a boat. It was filled in with dirt that washed off of the fields on tobacco farms.

Chesapeake Challenge

1. Test the erosion power of water with a sprinkling can of water, two pencils and two sheets of paper. Go outside and locate a place with grass and one with bare dirt. Put the pencils through the papers so that the papers look like a ship's sails. Poke one into a patch of bare dirt and the other in grass. Use the watering can to make it rain hard next to the papers. Which one gets dirty? What does this tell you about the value of plants in reducing erosion?

2. Compare the effect of a "hard" rain vs. a "gentle" rain on a pan of dirt, using a watering can. Collect the water as it runs off. Compare the effect of the same "rainfall" on a steep vs. a slight slope.

3. Test whether large particles of soil settle faster than small ones with a tall, clear jar, a lid, some water and some dirt. Shake the dirt and water in the closed jar and then let it sit. Are there differences in the size of the particles that settle to the bottom first?

Family Action

1. Visit a stream near your home with your parents right after a rain storm. What is the color of the water? Do you think this is due to erosion? (Be careful around streams.)

Chesapeake Challenge

1. Use a state or local map to find the name of roads or towns that have the word mill in them. How many can you list? Can you find the stream or river that provided the water power for each?

2. Work with others to design a water wheel that lifts a weight. You will need to do some library research on how wheels were designed in the past. If you are doing this for school, have a contest to see which group can make the water wheel that lifts a one pound weight the highest with one gallon of water poured no more than six inches above the wheel.

3. List the large, modern dams you find on your state map. Hint: look for lakes created by the dams.

4. Draw or make a model of a dam with a fish ladder.

Family Action

1. Plan a visit a mill that still works. There are a number of mills operating as museums. Here are several:

Maryland

- Union Mills Homestead and Gristmill, Carroll Co., MD

Virginia

- Tackett's Mill, Occoquan, VA
- Woodlawn Plantation, Fort Belvoir, VA
- Wade's Mill, Raphine, VA
- Mabry's Mill, milepost 176, Blue Ridge Parkway, VA

Using Water Power

Water power was used to do all kinds of work that we do with electricity or fuel today. Places that used water power were called mills. Water turned a large wheel. A system of gears and belts made that turning motion drive machines. Mills used water power to grind corn or wheat. Moving water also ran machines which wove fabric, cut lumber, shaped metal and ground ore.

Where land sloped and water ran downhill, a dam was built to force water to flow to the water wheel. Sometimes mill ponds were made to insure a steady flow of water all year. Where the land was flat on the coastal plain, tidal creeks were closed to make a narrow opening through which the tide ran very fast in and out. A mill wheel was put in the opening. The gears in the mill were designed so that the wheel could turn either way.

Today rivers are dammed to generate electricity. The water turns a wheel inside the generator instead of a mill wheel. We often use electric power to do the same things people used to do with water power: grind grain, mill lumber and weave fabric. The large dams which make electricity also store water so that we have a constant water supply.

One problem with dams on streams and rivers is that they block the path of fish that must swim upstream from the ocean to fresh water in order to lay eggs. Some big modern dams may have "fish ladders" which make a "stream" around the dam where fish can swim uphill over a series of little waterfalls. Dams remain a problem for spawning fish, like shad and herring. In modern times the pipes that carry streams under roads may also create waterfalls that fish cannot get over. One estimate is that there are more than 750 places on Maryland streams that stop fish from swimming upstream to lay their eggs.

undershot water mill

Travel and Trade in Early Times

Native Americans of the Chesapeake region traveled and traded over a wide area. They used large log canoes to travel by water. They also had a system of trails through the forests, many of which became our roads. The larger loads of the early European settlers were most easily shipped by water. As a result their farms and villages grew along the shores of the Chesapeake and up its rivers. The Bay and its rivers determined where these people took land and started farms. For the first two hundred years of European settlement, ships and boats were the most important transportation in the Chesapeake region.

Towns for trading and shipping were started as high up rivers as boats and ships could go. In some cases this was determined by the depth of the water. But many towns were established on rivers at the "fall line," where the rolling hills (called the piedmont which means foot of the mountains) meet the flat coastal plain. This is the location of the last waterfalls as the river flows from the mountains to the Bay. Among the cities built on the fall line are Richmond, Virginia, and Washington, DC.

Until the 1800's when canals were dug alongside the rivers, the fall line was the point at which goods and crops had to move over land. The remains of canals can be seen along the James, Potomac and Susquehanna Rivers above the fall line even today. Boats were towed up and down the canal by mules or other animals. The C and D Canal which connects the upper Chesapeake Bay with Delaware Bay is still in use, not only by ships but also by migrating striped bass. When this canal was enlarged in modern times, it may have changed the flow of water in the upper Bay, causing problems.

Chesapeake Challenge

1. Locate Richmond, Washington and the mouth of the Susquehanna River on the Chesapeake Bay map on pages 30 and 31. Draw a dotted line with a slight curve connecting these points. Label it Fall Line. Use your state map to find and mark two other cities that were built on the fall line.

2. Locate and label the C and D Canal on the same map.

Family Action

1. Take a day trip to visit one of the old canals dug to take vessels up river above the fall line. Look for locks (water was pumped into or drained from a lock to raise or lower the boat), a tow path and tavern or lock keeper's house. Here are some places where parks have been made which include canals:

Maryland

- C and O Canal National Park Historical Park (upper center in Cumberland, MD and lower center at Great Falls, MD; lock #24 in Seneca, MD)
- C and D Canal, Chesapeake City, MD

Virginia

- The Tidewater Connection in Richmond, Virginia

Chesapeake Challenge

1. Discover the name of each Chesa-peake Bay ship by using the classification system on page 41. Start at the left hand side and make a choice between the first two characters after reading the card. Follow your choice to the next two characters. Keep going until you find the name of the boat or ship. Then turn the card over to check the name and learn more about the use and origins of this vessel.

Family Action

1. See these and other Chesapeake Bay boats and ships at these museums:

Maryland

- •Calvert Marine Museum, Solomons, MD
- •Chesapeake Bay Maritime Museum, St. Michael's, MD
- •Outdoor History Museum, St. Mary's City, MD
- •Patuxent River Park, Croom, MD
- •Potomac Museum, Coltons Point, MD
- •Baltimore Inner Harbor, Baltimore, MD

Virginia

- •Jamestown Festival Park, Jamestown, VA
- •Mariners Museum, Newport News, VA

2. Visit other museums in the Chesapeake Bay region that also have maritime history exhibits, but may not have boats or ships. These would be fun if you are interested in the history of shipping or fishing in the Chesapeake Bay region. They include:

Maryland

- •Chesapeake and Delaware Canal Museum
- •Crisfield Historical Museum, Crisfield, MD
- •Neild Maritime Museum, Cambridge, MD
- •Oxford Museum, Oxford, MD
- •Radcliff Maritime Museum, Maryland Historical Society, Baltimore, MD

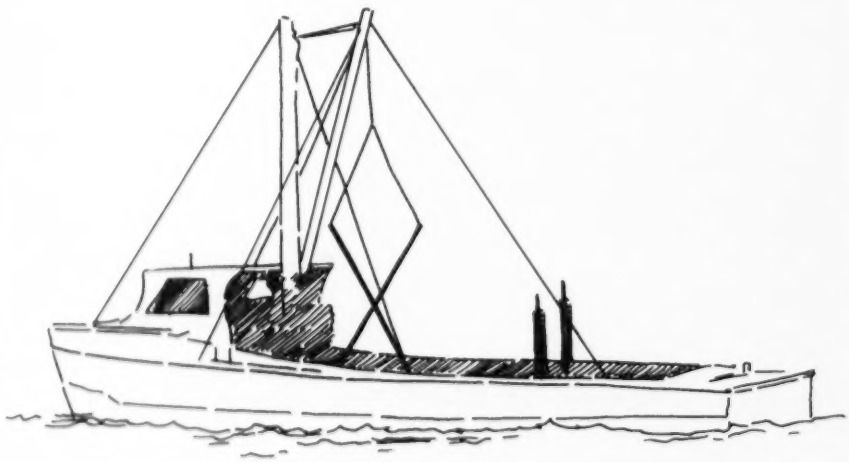
Virginia

- •Chesapeake Bay Watermen's Museum, Yorktown, VA
- •New Comfort Point Lighthouse Museum, Mathews, VA

Working Boats and Ships of the Chesapeake Bay

Literally hundreds of kinds of boats and ships have sailed the Chesapeake Bay. They have served every possible use: transportation of people and cargo from across a creek or around the world, fishing, fighting wars and racing. There are some that are unique to the Bay. Nine of these working boats and ships are pictured on cards on the next page, along with a description. If this is your own book, you might want to cut them out. Check with your teacher or parent first.

When reading the cards, you may find words that describe the ships or boats that are new to you. Here are some boat terms to remember. The bow is the front (forward) of the ship and the stern, the back (aft). The poles that hold the sails upright are called the masts. A sloop has one mast while a schooner has two or more masts close together. Sometimes they have additions to the masts called topmasts. Raked masts are tilted backwards toward the stern.



1 _____

2 _____

3 _____

4 _____

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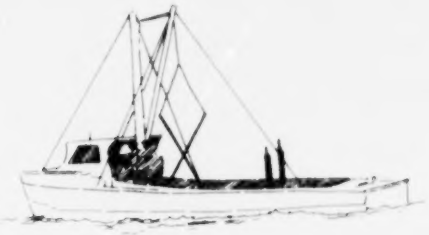
7 _____

8 _____

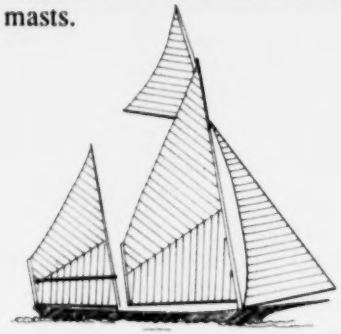
9 _____ 44

1. Powered by a motor (often an old car engine), these boats are usually 30 to 45 feet long, with a small cabin in front and a covered deck.



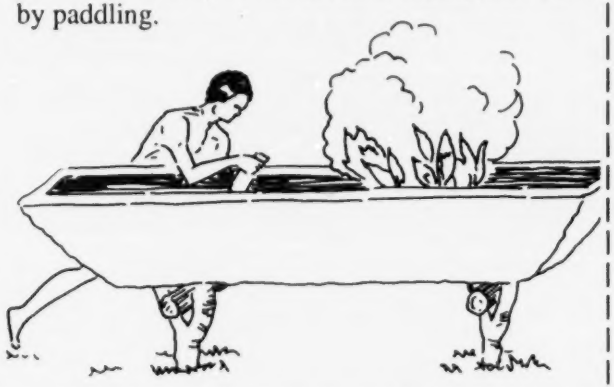
2. Graceful, sharp bow and squared stern; a single mast with sloop rigged sails.

3. Both ends are pointed (double-ended); made from five logs carved with metal tools; two removable masts.

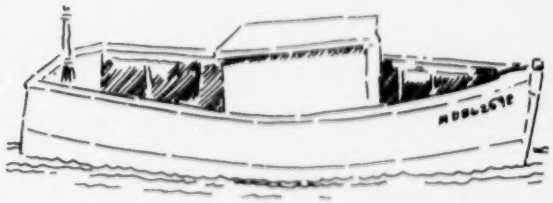


4. Schooner rigged with two raked masts and topmasts, this very fast ship carried cargo all over the world in record times.

5. Both ends are pointed (double-ended); moved by paddling.



6. Powered by a motor (usually an old car engine), these little boats are towed or hang behind sailing ships. They are open, but may have a housing over the motor.



7. Schooner rigged with three or four masts; very long and narrow, with straight sides; slow and bargelike.

8. Both ends are pointed (double-ended): made of shaped boards; one mast fixed.

9. Schooner rigged with two curved, raked masts, the second with a topmast; fast sailing ship 54-76 ft long.

SAILING LOG CANOE These ships evolved from the log canoes used by the Native Americans, rigged with sails. These open boats were fast but offered little protection from the weather. They are still used today for races.

SKIPJACK As oysters became scarce, these smaller craft with fewer crew members were made for dredging. Some 30 were still licensed to dredge in 1980, the last commercial sailing fleet in the United States.

DEADRISE Named for the straight from the center to the side of the bottom, these boats are the most common watermen's workboat today. They may be rigged for crabbing, oyster tonging or clam dredging. In between times, they are used for fishing.

YAWL BOATS These little boats evolved from the small craft carried by sailing ships which were rowed ashore. They work as mini tugboats, pushing or pulling sailing ships. On the days oyster dredgers are allowed to use a motor, these little "push boats" provide the power for the skipjack.

LOG CANOE These were made from a single log by Native Americans. They were hollowed out by repeatedly burning and scraping the burned area. Some were as much as fifty feet long.

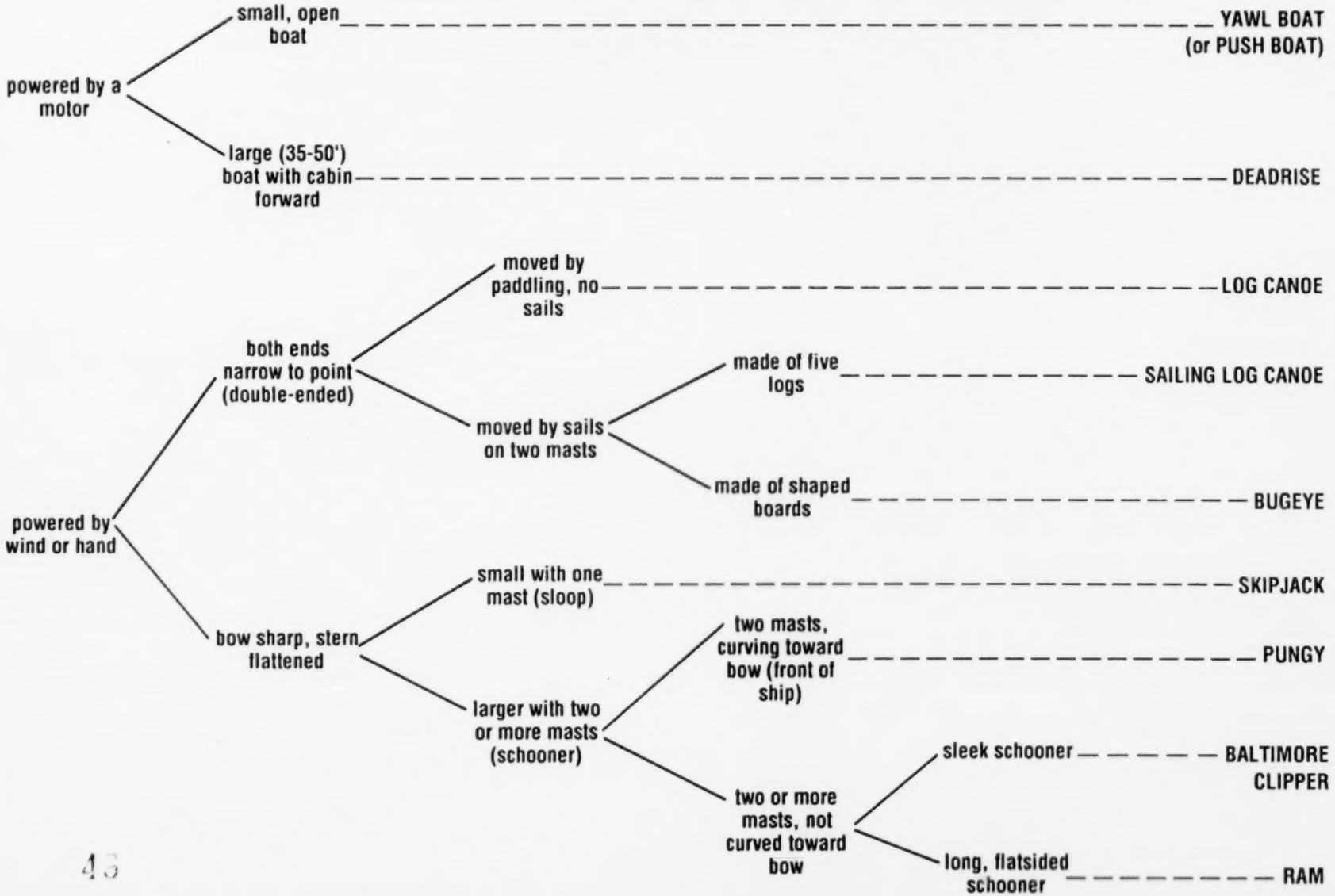
BALTIMORE CLIPPER These fast and graceful ships evolved from those used by privateers and blockade runners during the Revolutionary War. They were common in the first half of the 19th century, but were replaced by steam ships and trains.

PUNGY These swift ships evolved from the Baltimore clipper, but were designed for use on the Bay where they frequently carried perishable cargo from port to port. They were the first ships used for oyster dredging. Like the early skipjacks, they were painted pink and green. Their deep draft kept them out of shallow water.

BUGEYE These graceful ships towed oyster dredges and hauled vegetables, lumber, and coal. They were also sailed by pirates and whiskey smugglers. They evolved from log canoes, but were larger and had a covered deck and cabin forward.

RAMS These long narrow schooners were designed to be sailed through the 24 ft wide C and D Canal at the top of the Bay. They were really only sailing barges, but some brave sailors used them in the ocean too.

Key to Some Chesapeake Bay Boats and Ships



Chesapeake Challenge

1. Write letters to the Maryland and Virginia departments that regulate fishing and ask for copies of the regulations for sport and commercial fishing, oystering and crabbing in the Chesapeake Bay. Compare the regulations. How are they the same? Different? Why do you think the two states do not agree?

Maryland Department of Natural Resources
Tawes State Office Building
580 Taylor St.
Annapolis, MD 21401

Virginia Fisheries Management Division
P.O. Box 756
Newport News, VA 23607

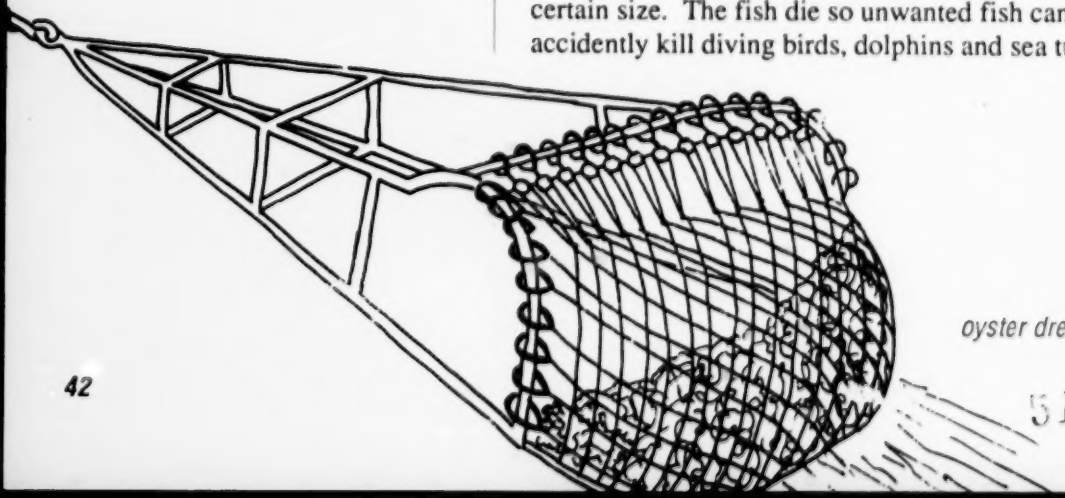
Fishing the Bay

The animals of the Chesapeake Bay are an important source of food. The early settlers learned to fish from the Indians. Studies by archaeologists show that in addition to collecting crabs and oysters, the early colonists commonly used a hook and line to catch fish. This was done from shore with little equipment. As tobacco plantations grew and there were more mouths to feed, the colonists learned to harvest the huge seasonal schools of shad and herring, using large nets and many persons. With ever larger nets, it was possible to catch almost all of the fish swimming upstream to lay their eggs, greatly reducing their numbers.

Oysters once covered 2300 square miles of the bottom of the Bay. People learned to take oysters with scissor-like tongs. In the early 1800's the New England oyster beds were over fished so the Yankee dredge boats came to the southern Chesapeake. They collected oysters by dragging a heavy iron scraper and chain net across the oyster beds which damaged the beds. In 1810 Virginia outlawed dredgers, allowing only the less destructive tongs. Maryland waited until 1820 to outlaw dredging. By then the Maryland watermen had learned to make dredges. They used them illegally, until dredges were made legal in Maryland around the time of the Civil War.

Many rich oyster beds were on the boundary of Maryland and Virginia. Watermen from the two states fought over the oysters and the ways they were taken. In the late 1800's the "Oyster Wars" became so bad that both states created oyster police to enforce the laws protecting oyster beds. Pirate dredgers operated out of both states. The tongers and dredgers did some shooting, too. The last men to die in the Oyster Wars were killed in 1959. A current argument concerns taking oysters using SCUBA. Overharvesting and disease have so reduced the oysters that there are hardly enough to fight over.

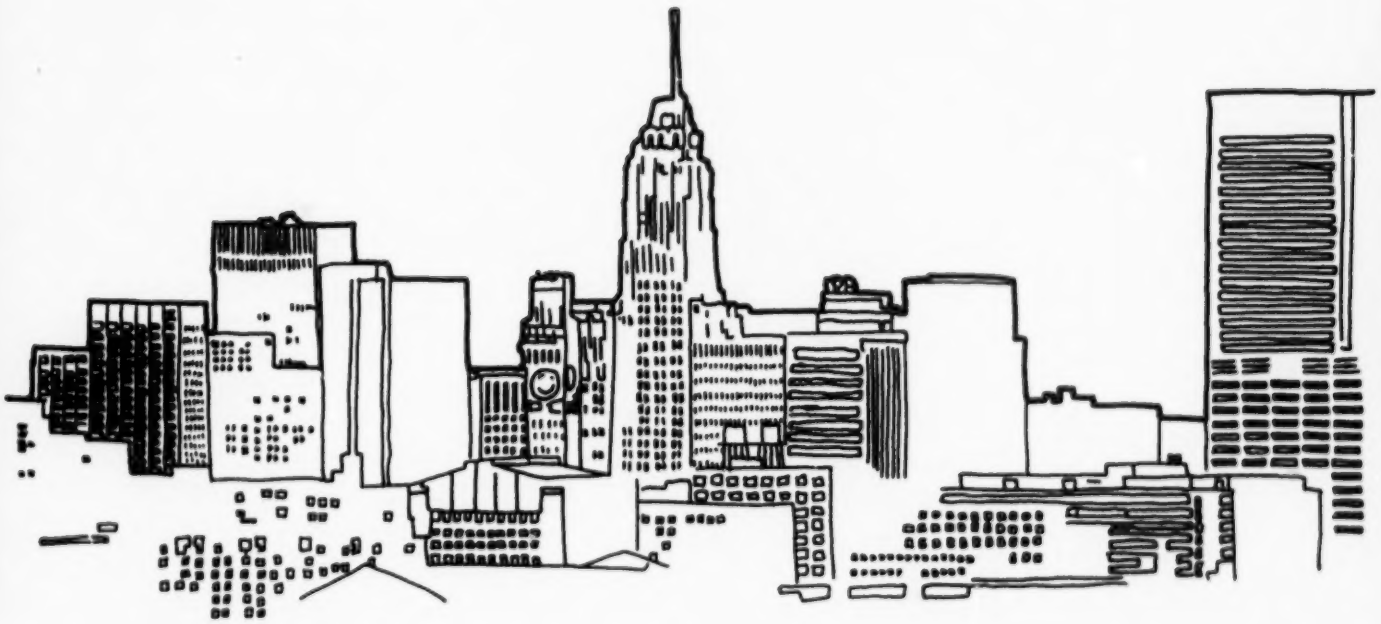
Some old fishing ways are still used. Pound nets are based on Indian designs for trapping fish alive. Only the valuable fish are taken and the rest released. People still use baited "trot lines" for crabs. On the other hand, most crabs caught for sale are taken in wire traps. Clams are dredged from the muddy bottom with a mechanical digging system mounted on a boat. Some new fishing methods threaten to wipe out the few remaining fish of some species. Gill nets catch fish as they try to swim through the wide holes in the net. They catch all fish over a certain size. The fish die so unwanted fish cannot be released. The nets accidently kill diving birds, dolphins and sea turtles.



oyster dredge

The Chesapeake Bay Today

The Chesapeake Bay today is different from the way it was when Europeans first came. The actions of all people living around the Bay have changed it. This section will help you understand the results of the changes we have made in the watershed and the Bay. It will also talk about changes we can make in the way we live that will help the Bay in the future. Each of us is responsible for the future of the Chesapeake Bay.



Chesapeake Challenge

1. Here is a series of cards that show some of the kinds of habitats people have created in the Chesapeake Bay watershed. First, look at the picture and text to see if you can predict what kind of habitat you have based on your observation of the picture. Then use the chart on page 47 to identify it. At each step you will decide between two choices. Follow your choice to the next pair of choices until you identify your habitat.

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

2. Predict the ways that each human habitat might affect the Chesapeake Bay. Then turn the card over to check your answer and see if your predictions are correct.

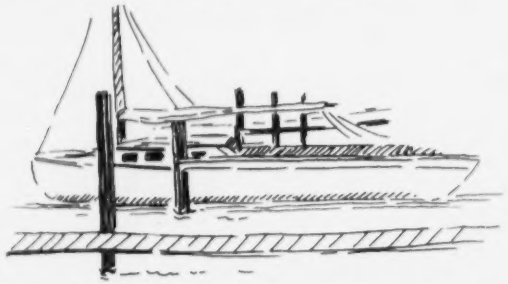
Habitats in the Chesapeake Bay Watershed Today

When Europeans came to the Bay, the land was covered in forests with scattered Native American villages. The land around the Bay has changed tremendously in the last 350 years. You have learned about the natural habitats of the Chesapeake Bay and the plants and animals that live there. All of them are affected by the changes in the Chesapeake Bay watershed. Our lives on land have a direct impact on the Bay. Can you identify the human habitats we have created in the Chesapeake Bay watershed during the last 350 years and the ways they affect the Bay?

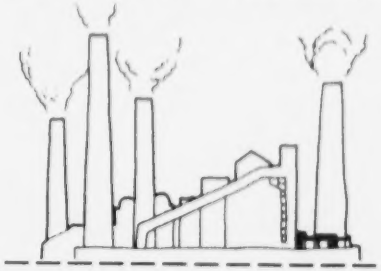
Chesapeake Bay Tour Boat

1. People live in scattered houses with large lawns and some small trees located at a distance from the center of a city; may be mixed with farms. People must travel by car to work or shop

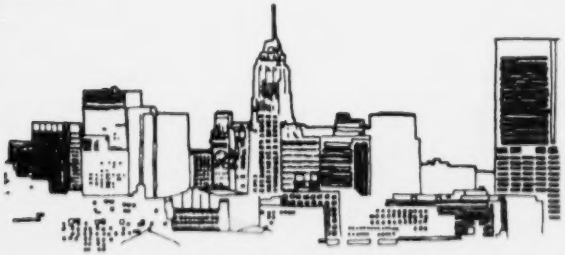
2. Large numbers of small boats which people use for recreation or fishing are kept here. They are used on the Bay, lakes or rivers.



3. People earn their living here processing raw materials such as making steel and chemicals, manufacturing things ranging from computers to cars, and producing electricity.

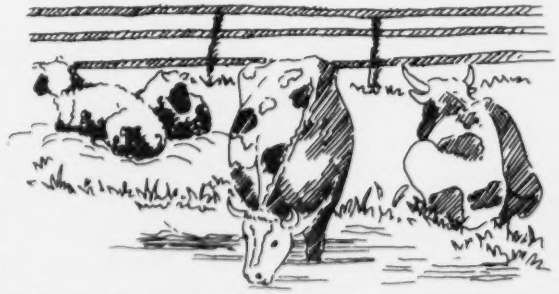


4. People live here in large numbers in apartments or homes. They work in offices and buy things they need in shopping centers. They travel mostly by car, but buses are also available.

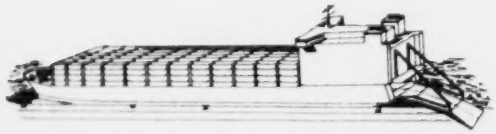


5. Trees grow on their own from seeds spread by wind or birds. Many kinds of animals live here. People may hike, hunt or fish in the streams here.

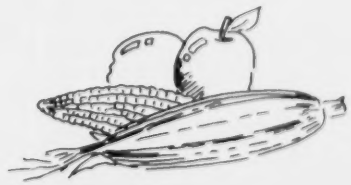
6. Fields of grass or grain may be grown to feed the animals grown here, but feed is also brought in from other places. The animals often live in buildings or barns.



7. Big ships from all over the world come and go, bringing things to us and taking our products to others. These places are located near roads and railroads for land transport of these things.



8. Fields of corn, wheat, soybeans, tobacco or vegetables cover the land or rows of trees, all of the same kind, are grown close together. We eat some of these crops directly while others are fed to the animals we eat.



9. These are places that people dump things such as trash, garbage or waste products from factories. They may be in the country in open fields or in cities near people's homes. Some animals like sea gulls and rats may live here.

FACTORIES OR INDUSTRIES Mills, processing plants, chemical plants, and factories use water in many ways. They may use it to cool things which heat the water too hot to support animal life. They may use the water as a place to dispose of hazardous chemicals and metals. Factories often make toxic wastes that are dumped in landfills.

MARINAS Thousands of people own boats which they use on the Bay and on lakes and rivers in the Bay's watershed. These small boats contribute to pollution in several ways. Oil and gasoline may leak or spill into the water. The paint used on the bottoms of the boats has chemicals which kill animals that might grow there. The chemicals enter the water and kill zooplankton in marinas. People use bathrooms on these boats and their sewage may enter the water. People also throw trash and old fishing lines and nets in the water, littering it. Plastic trash may kill animals that become caught in it.

OUTLYING OR RURAL DEVELOPMENTS When cars and roads became available, people moved greater distances from towns. Farms and forests were developed into houses built on large lots. Good farmland that fed people and forests where wild animals and plants lived is now covered in mowed grass. These houses get water from wells that reach down to the groundwater. They dispose of sewage with septic tanks which treat the water a bit and return it to the ground. Household chemicals like soaps and cleaners also enter the groundwater. Groundwater seeps out as springs that run into streams, carrying these wastes to the Bay. Fertilizer, pesticides (kill insects) and herbicides (kill weeds) used to grow pretty lawns wash into streams when it rains. They are carried to our drinking water and into the Bay.

FARMS FOR ANIMALS Farms that raise animals may produce chickens or eggs, beef or milk, pork or lamb. Some farms that raise cattle or sheep keep them out on pasture all year. If the grass is not overgrazed and the animals are kept fenced out of the streams, this kind of farm does not pollute water. Farms where the animals are kept close together and food is brought to them have manure problems. It washes into streams. Most farms are old. Farmers used to put their animals where the manure would wash away on purpose. These old farms need to be changed to keep the plant nutrients in manure out of stream.

FORESTS Forests help rain and melted snow slowly sink down into the soil to become clean groundwater. Forests prevent rapid runoff and soil erosion during storms. They even absorb some of the wastes that farm and city runoff picks up such as fertilizer and eroded soil, preventing these things from entering streams, rivers and the Bay. Trees shade streams, keeping the water cool for fish in summer. Trees also absorb carbon dioxide from the air and might help reduce the greenhouse effect.

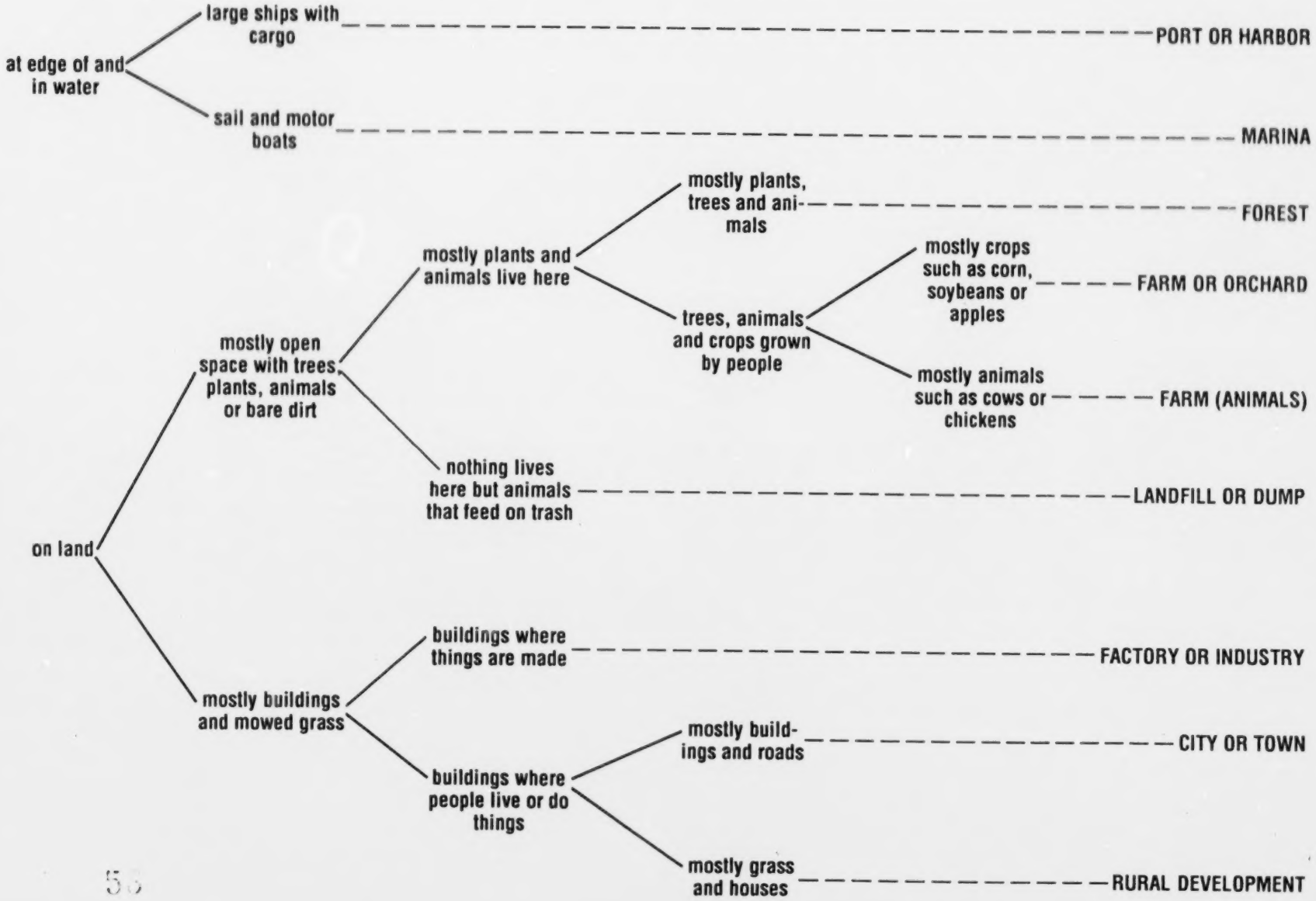
CITIES OR TOWNS People in cities dispose of human waste and household chemicals through a sewer system which carries these things to a sewage treatment plant. Industrial wastes may also go to sewage plants. Salt put on roads and sidewalks to melt snow and ice runs off into storm drains. Spilled oil or gasoline also washes into storm drains. Fertilizer, pesticides and herbicides run off lawns when it rains and enter storm drains. Storm drains empty into streams or directly into the Bay, carrying all these harmful materials.

LANDFILLS OR DUMPS Landfills or dumps get thousands of kinds of stuff dumped in them, from household garbage to toxic chemicals and low level radioactive waste. If they are carefully constructed and properly run, they are relatively safe. Many are old and leak. Some are beside the Bay and flood during storms or especially high tides. Rain soaking through the landfill picks up all kinds of chemicals and carries them down to the groundwater below. People do not want to live next to a dump. As the population grows, making more and more garbage, there are fewer places to put it.

FARMS OR ORCHARDS Farms that grow crops and orchards expose the soil to erosion when it is plowed. Muddy water flows into streams and rivers. Fertilizers containing nitrogen and phosphorus are used to increase plant growth. Pesticides are sprayed to kill insects. Herbicides are sprayed to kill weeds that would compete with the crops. Some of these chemicals enter the groundwater. These chemicals may also enter streams and rivers as part of storm runoff.

PORTS AND HARBORS Ships can pollute the Bay in many ways. There may be accidental fuel oil leaks. They must dispose of their human waste and trash. It is tempting to dump both. Occasionally a ship breaks or runs aground and loses its cargo which might be oil or a hazardous chemical. The big propellers which drive the ships stir up the bottom and make the water muddy. Perhaps the worst problem with shipping is that the Bay and its large rivers must be constantly dredged to keep the water deep enough for ships. Dredging stirs up the muddy bottom and releases hazardous materials buried in the mud. The mud that is dredged up has to be disposed of, either in some other part of the Bay or ocean or on land.

Key to Watershed Habitats of the Bay Region


at edge of and in water
large ships with cargo
PORT OR HARBOR
sail and motor boats
MARINA
on land
mostly open space with trees, plants, animals or bare dirt
mostly plants and animals live here
mostly plants, trees and animals
FOREST
trees, animals and crops grown by people
mostly crops such as corn, soybeans or apples
FARM OR ORCHARD
mostly animals such as cows or chickens
FARM (ANIMALS)
nothing lives here but animals that feed on trash
LANDFILL OR DUMP
mostly buildings and mowed grass
buildings where things are made
FACTORY OR INDUSTRY
buildings where people live or do things
mostly buildings and roads
CITY OR TOWN
mostly grass and houses
RURAL DEVELOPMENT

Chesapeake Challenge

1. Use your aluminum foil watershed to demonstrate serious erosion (see page 14). This time use a whole teaspoon of Kool-Aid sprinkled over the watershed to show what happens when housing developments, farms and road projects get hit by a big storm.

Family Action

1. Conservation of soil and prevention of erosion starts at home. Look at you yard. Are there places where your should plant grass or shrubs to protect your soil and the Bay?

2. Have you ever spotted erosion at a development? Each county has laws about erosion control. Report erosion from developments to the sediment control officer. Call county government information for his/her number.

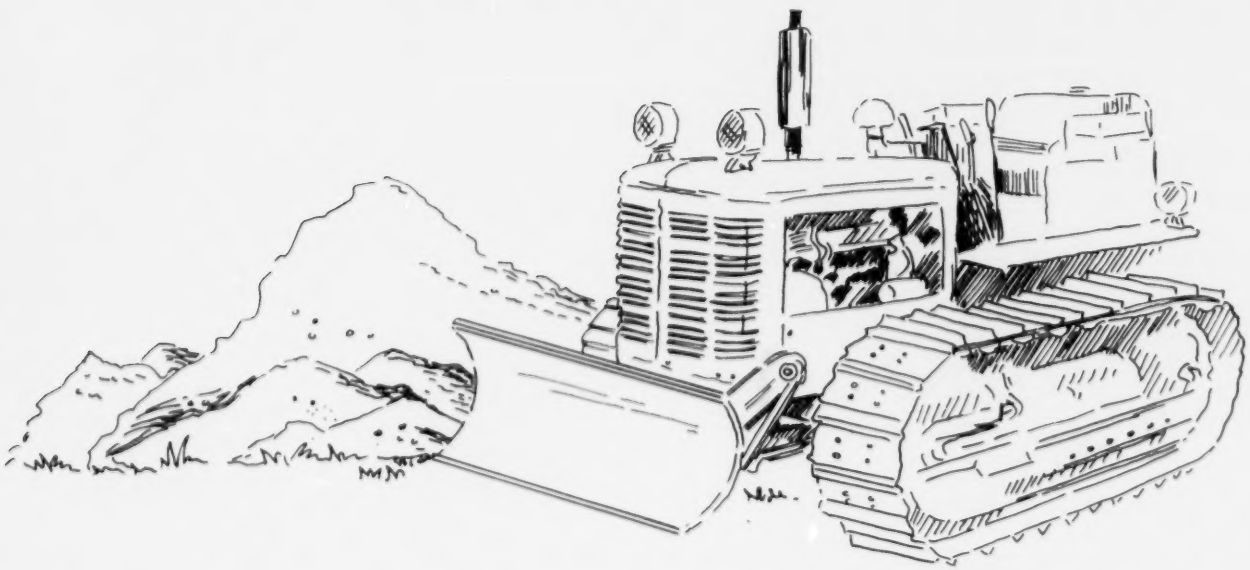
Muddy Water

When erosion takes place, dirt gets into the water. Muddy rivers carry this dirt to the Chesapeake Bay. Erosion happens on farms in plowed or overgrazed fields, along streams where plants have been cleared from the banks, in new housing and commercial developments where bulldozers tear into the soil, on road construction projects, along shorelines no longer protected by marshes or underwater plants, on the school yard where the grass has been worn thin by children's feet and in the yard at home where the soil is not protected by plants. The bits of dirt that make the water look muddy are called sediment.

Some problems with sediment in water are caused directly by the tiny particles of dirt. In streams and rivers sediment buries fish eggs and other animals. It clogs some animals' gills, keeping them from getting enough oxygen from the water. In the Bay and in lakes and ponds, dirt in the water blocks the sunlight from reaching the underwater plants. Since they need light to live and grow, they die. Sediment also fills in streams, rivers, lakes and the Bay.

Other problems caused by the interaction of dirt and water are not as obvious. The chemicals plants and phytoplankton need to grow are in soil. When dirt gets into the water, so do these chemicals or plant nutrients. The main nutrients that control plant growth are nitrogen and phosphorus. These nutrients get into the water (dissolve) and stay there even if the sediment settles out. When nutrients in the water are too high, phytoplankton grow faster than animals can eat them. Also, the balance of kinds of phytoplankton may change to those that are not as good to eat.

Some kinds of erosion are easier to control than others. Most counties have laws to control sediment on construction projects. Soil and water conservation districts work with farmers to prevent erosion, but there are no laws that enforce good farming.



Too Many Nutrients

Plant nutrients are needed for plant and phytoplankton growth and reproduction. One of the special things about an estuary is that there are enough nutrients to support a great deal of plant growth so there is a lot of food for animals. But is there such a thing as too much of a good thing? Yes. Bay scientists call it nutrient enrichment. An algal bloom occurs which means overgrowth of phytoplankton. The kinds of algae that increase may not be those that animals eat.

Where do the plant nutrients come from? Nutrients enter the water with soil. Human sewage and animal manure are both rich in plant nutrients, including nitrogen and phosphorus. Manure is used in gardens and on fields to increase growth. Milwaukee makes its human sewage into lawn fertilizer. Although sewage is treated, it still contributes nutrients when the treated water is released into a river or the Bay. Manure frequently washes into streams with runoff and eventually gets to the Bay.

Most garden, farm and lawn fertilizers are made from chemicals rather than manure, but they also contain nitrogen and phosphorus. If they are applied just right, the nutrients end up in the plants. But it is hard to do correctly. Most people use too much fertilizer. It washes off of lawns, gardens, golf courses, and fields and into our water supply and the Bay. It also soaks into the ground and gets into the ground water.

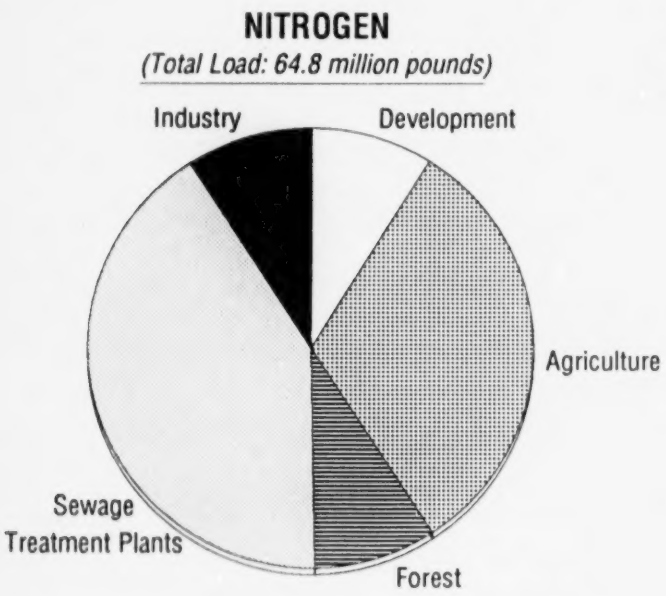
Chesapeake Challenge

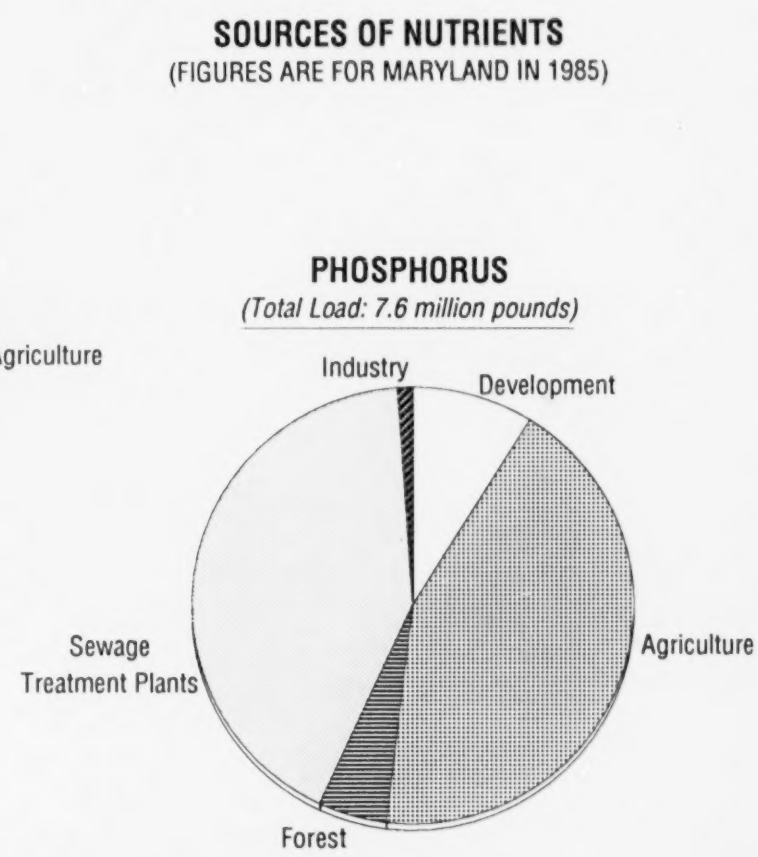
1. Use the Habitats of the Chesapeake Bay Watershed cards to make a list of the kinds of habitats that add plant nutrients to rivers, lakes and the Bay.

2. Identify one habitat that protects the Bay from nutrients.

Family Action

1. If you have a lawn, your family can reduce its contribution to Bay pollution by reducing fertilizer use. Remember, never before predicted rain. Be careful not to overwater your lawn. It also helps to let your grass grow longer than most people do. The longer blades of grass reduce runoff and help the rain soak into the ground. A longer lawn survives dry periods better, too.





Chesapeake Challenge

1. Use the Habitats of the Chesapeake Bay Watershed cards to make a list of the kinds of habitats that add toxic materials to rivers, lakes and the Bay.

2. Use your aluminum foil watershed (page 14) to see what happens when a factory dumps toxic waste in a river. Use a drop of food coloring high up in the watershed to represent the toxic waste. Where does it go when rain falls?

Family Action

1. With a parent, do an inventory of your household chemicals. List those that are toxic. Identify them by reading the warnings on the label. Discuss whether you really need the product. Do you use it safely? Do you store it safely?

2. Does your family change the oil in your own car? What do you do with it? Never dump it on the ground or down a storm drain. Take it to a gas station to be recycled.

3. *Baybook* from the Alliance for the Chesapeake Bay (see the back page) will help your family understand what to do with hazardous chemicals in your home as well as help the Bay in other ways. Contact them for a copy.

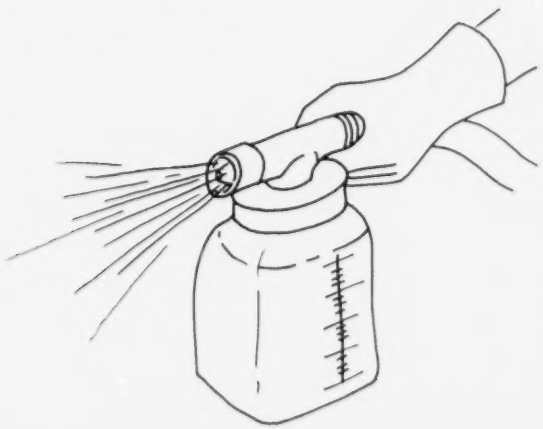
Toxic Materials in the Bay

A chemical is said to be toxic if it harms or kills plants or animals by direct action. Many different kinds of materials are toxic. The amount of the material may be important. There are some things that are needed or harmless in small amounts and deadly in larger amounts.

Some Bay toxic things are the heavy metals. They include materials like lead, mercury and chromium. They get into the water when they are refined near water or are used in a manufacturing process. For example, the bottom of Baltimore Harbor is rich in chromium because there was a plant that processed chrome ore by the harbor. Chrome is used to plate steel to make it shiny.

Organic compounds are based on carbon as are the chemicals made by living things. Oil is an example of an organic compound that is the remains of things that lived millions of years ago. There are a number of organic chemicals which we have learned to make and use in the last 50-100 years. These are new chemicals. For many there are no bacteria or other things that break them down so they may remain long after they were used. Some of them are toxic to plants or animals. Pesticides and herbicides are organic compounds that are made to kill insects (pests) and plants (herbs). Some organic chemicals get into the water accidentally as with an oil spill or pesticide in runoff. Others are disposed of intentionally by dumping them in the water. PCB's are an example of this. There are also toxic chemicals that are not organic compounds. Some are very simple such as acids from manufacturing or acid rain. Others are more complex chemicals.

There are toxic chemicals in your home as well as in factories. Many of the cleaning compounds under your kitchen sink are harmful to you if you drink them just as they are to animals and plants that live in the water. Sewage treatment plants and septic tanks do not remove many toxic chemicals. The best way to deal with industrial chemicals is to treat them at the factory so that the treatment plant can be designed for that single problem. Household chemicals should be used sparingly.



Too Many Phytoplankton and No Oxygen

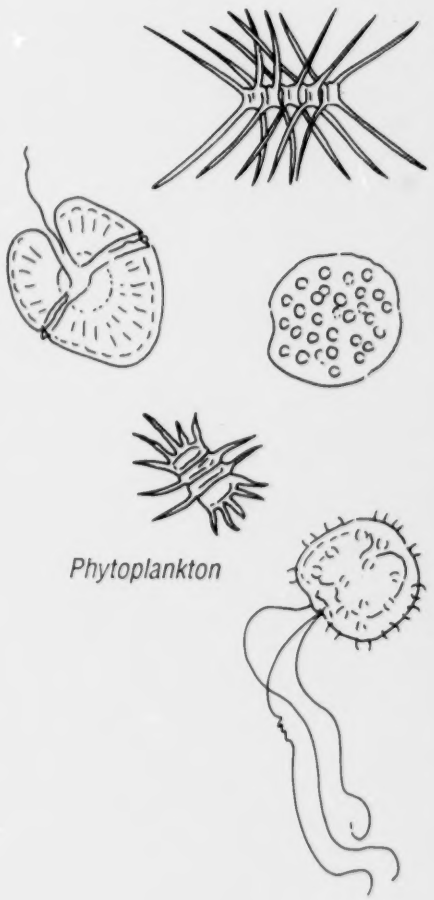
The plant nutrients entering the Bay are especially high in the spring when heavy rains carry farm fertilizer and manure into the rivers and down to the Bay. The phytoplankton respond with an increase in growth and reproduction. Longer days and warmer temperatures in the spring also help them grow. The numbers and kinds of algae are more than the zooplankton, oysters and other algae feeders can handle.

Phytoplankton sink to the bottom and die. There they become food for bacteria. As the bacteria feed and increase in numbers, they use oxygen from the water. Oxygen enters the water at the surface and is also added by plants and algae near the surface. It gets to the bottom very slowly unless winds stir up the water. Before long, the bacteria use up all the oxygen in the bottom water. When the water has no oxygen, it is called anoxic meaning without oxygen. Animals that live on the bottom that cannot move such as clams and oysters may die if there is anoxia for several weeks.

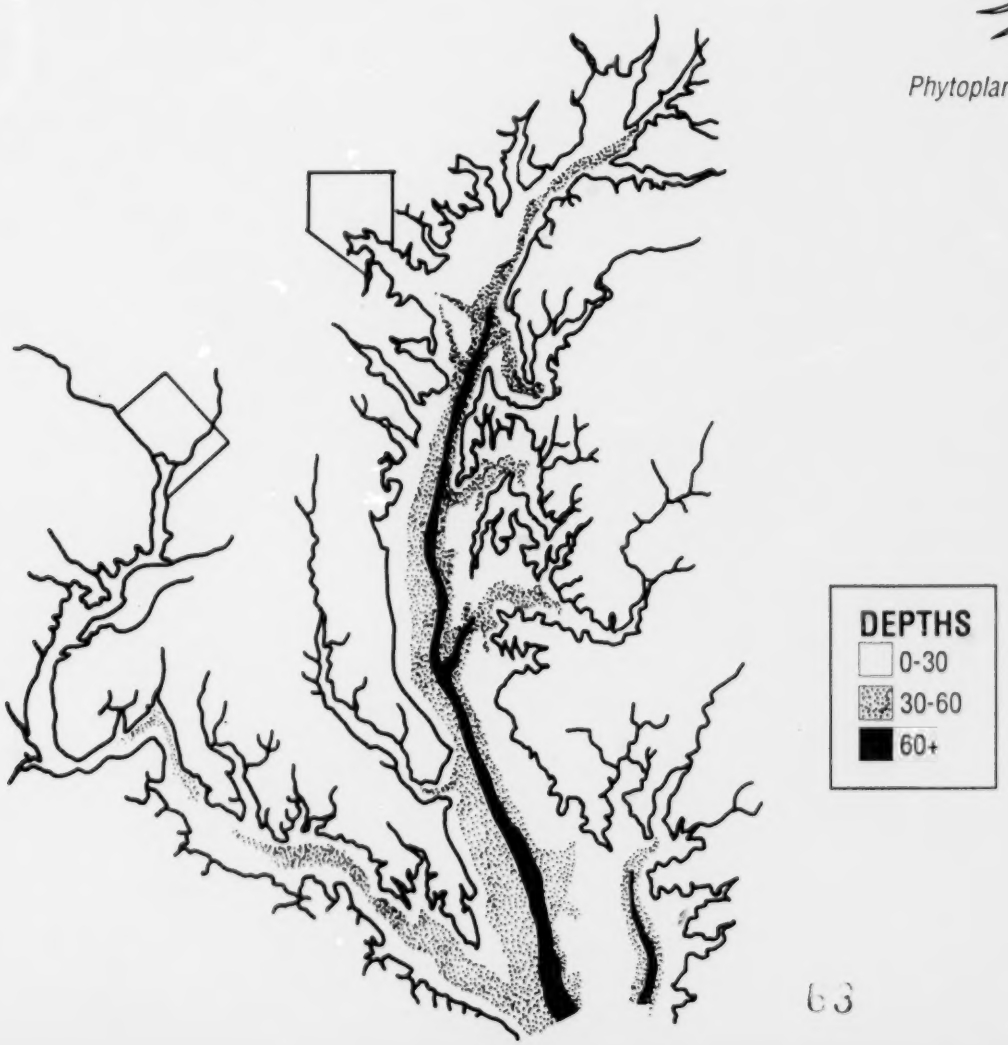
Periods of low oxygen in the deeper water of the Chesapeake Bay have been occurring for many years. Anoxia in shallower water appears to be increasing, but scientists do not all agree. There is agreement that periods of anoxia do kill Bay animals.

Chesapeake Challenge

1. Look at this map that shows how deep the water is in different parts of the Bay. Based on what you read, predict the places in the Bay that are most likely to have low oxygen.



Phytoplankton



Chesapeake Challenge

1. Imagine you are a tiny blue crab only an inch across. It is time for you to molt. Both fish and larger crabs would like to eat you while your new shell is soft. Write a story about searching for and finding a bed of underwater plants. What are your adventures?

Family Action

1. If your family has a home along the edge of the Chesapeake Bay or one of its rivers, consider trying to help a grass bed grow there. Contact your state department of fish and game for suggestions.

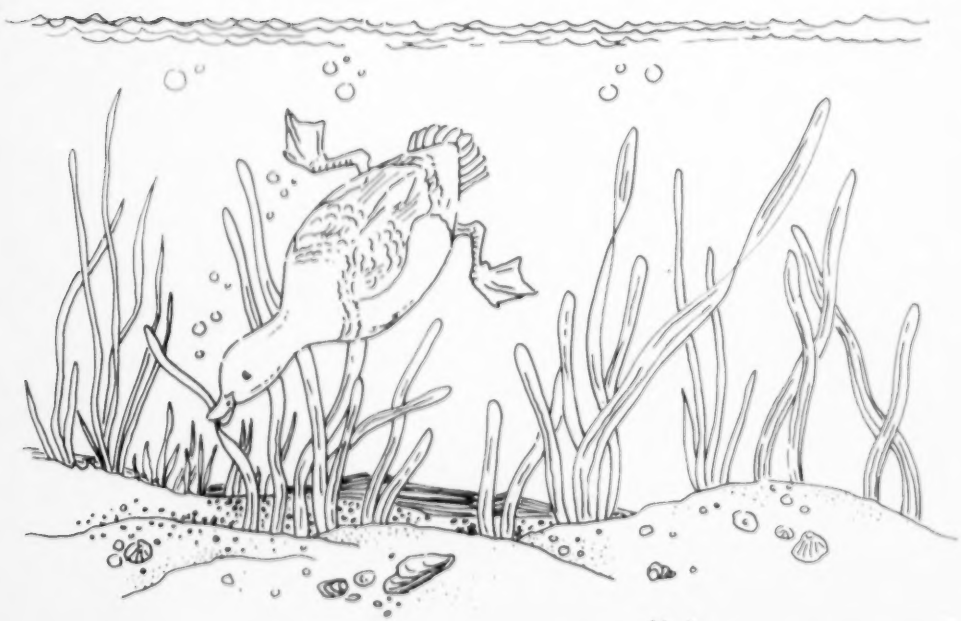
Lost Underwater Grass Beds

There are many things that tell us the Chesapeake Bay is in trouble. Decreases in striped bass and oysters provide clues. Perhaps the most obvious clue was the decrease in the beds of underwater plants generally called grass beds (both seagrass and weed beds). Different kinds of underwater plants are found in different parts of the Bay, but they are all widely recognized by both citizens and scientists as being important for the survival of many different animals.

Many of the grasses are important food for the ducks and geese that spend their winters on the Bay and its rivers. Deer, beaver and muskrats also feed on some kinds of underwater plants. The grass beds support many small invertebrates such as snails and tiny crustaceans which were food for young fish. Small fish hide from the larger fish that eat them in the plants. Molting blue crabs hide there while they are soft-shelled and weak. Not just underwater plants are hurt when the grass beds decrease.

Grass beds help protect the shoreline from erosion by decreasing the force of the waves. They also slow the movement of the water, causing bits of dirt (sediment) to settle out, so they help keep the water clearer.

Why did it happen? Some kinds of underwater plants died from natural diseases, but that could not explain the widespread decrease. At first everyone thought the herbicides which farmers were using in increasing amounts were to blame. Scientists do not think this is the problem. In several cases new kinds of plants were introduced by humans. These new plants crowded out the natural plants. Today scientists think the main problem with most grasses is that the water in the Bay is so muddy from erosion and so full of phytoplankton that the underwater plants which grow rooted to the bottom are not getting enough light. Sediment control and a decrease in nutrients may help the grass beds recover. People are also experimenting with replanting some grasses.



The Problem is People

Years ago a cartoon character called Pogo told us the truth about our environment and its problems. "We have met the enemy. It is us." People use things and make waste. We always have. We study ancient cities by the garbage they left behind.

There were fewer than 200,000 people living on the 64,000 square miles watershed of the Bay in 1600. Now more than 13,000,000 live there. The watershed of the Chesapeake Bay is filled with people and more are being added every day. At first it was our farming practices that hurt the Bay during the colonial times. We cut forests for firewood and lumber, or just to clear the land for farming. Then we built mills and factories that blocked rivers and dumped waste in the water. We built cities with more people, sewage and trash. Along the way we learned to catch more fish and oysters than were good for tne Bay. We built roads and parking lots which keep water from soaking in and increase runoff. We learned to make all sorts of new chemicals and fertilizers that hurt the Bay.

Something we have not done very much of is plan our growth. The area around the Chesapeake Bay is one of the fastest growing in the country. It is a good place to live and work. But if we do not start being more careful about where and how we build homes, roads and shopping centers, it may not be a nice place in the future. We have already damaged the Bay. Will we destroy the watersheds and rivers that provide our drinking water?

Land use planning is currently regulated by county governments. All too often short term gain is judged more important than long term benefits. If the Chesapeake Bay and its watershed are to survive, we may have to change the way we use the land.

Chesapeake Challenge

1. Work with several other children to draw a plan for an ideal town on a river near the Bay. Some of the problems you need to solve are food and water supply, transportation, waste disposal, sewage treatment, places to work, schools, housing, recreation and shopping. At the same time, remember to take care of the river, the Bay and the watershed.

Family Action

1. Find out when the planning commission for your city or county meets. Attend a meeting with a parent.

Chesapeake Challenge

1. Write a letter to one of the Chesapeake Bay groups listed on the back page. Tell them where you live and how old you are. Ask what you can do to help the Bay.

Family Action

1. Join one of the groups that works to help the Chesapeake Bay listed on the back page. Work on one of its projects such as a stream clean up.

Meeting the Challenge

Bay area congressmen and women, particularly Senator Mathias of Maryland, convinced the Environmental Protection Agency (EPA) to study the Chesapeake Bay in the early 1980's. Enough was learned to encourage the governors of Maryland, Pennsylvania and Virginia and the mayor of the District of Columbia to sign an agreement to work together to save the Bay. The agreement includes a set of goals which the states are working to meet. Scientists do not have all the answers to what is wrong with the Bay. The feeling is that if we wait until we know exactly what all the problems are, we will not have anything to save. Some of those goals include a reduction of 40% in nutrients entering the Bay, a program to create forests along streams, rivers and the Bay's shores and programs to protect critical areas from development. The project to study the Bay and to clean it up is being done by many agencies of the federal government and the states, working in cooperation.

The EPA provided a group for citizens' input to the program which has continued to serve as a source of Bay information. It was called the Citizens Program for the Chesapeake Bay, but has recently changed its named to the Alliance for the Chesapeake Bay. It has worked hard to help the Bay agreements come about. The Alliance also serves as an information clearinghouse and lets everyone know what to do to help the Bay.

Another Chesapeake Bay organization is the Chesapeake Bay Foundation (CBF) which grew out of concern for the disappearance of Bay habitats and wildlife. Like the Alliance for the Chesapeake Bay, CBF tries to work with government, business, industry, scientists and citizens to help the Bay. In addition to research and preserving habitats, CBF runs a huge education program for middle and high school students and teachers which takes them to the Bay to study it for themselves.

There are many other groups that also help the Bay, from the Izaak Walton League to Save our Streams to local school district projects like the Gunpowder Action Project of Baltimore County or the Severn River Monitoring Program in Anne Arundel County.

Forests to Help the Bay

We have started to clean up the water we use and send to the Bay in pipes. Sewage and industrial wastes are getting better. But what about all of the things that enter the Bay with runoff? It flows into every stream and river.

When Captain John Smith described the Chesapeake Bay, the Bay was healthy and the watershed was covered with forests. We cannot return to that time, but we can do something about the forests. Biologists have discovered that even narrow strips of forests along streams, rivers and the Bay's shore help protect the water from the effects of runoff. A strip of forest as little as 50 feet wide removes much of the sediment, phosphorus and nitrogen as the water flows through and soaks into the soil. Runoff from large areas of pavement like parking lots and roads also is helped by forests.

Planting forests along stream and river banks helps many kinds of animals too. The trees shade the water and keep it cool for fish in summer. Animals like crayfish find homes among the tree roots. Leaves that fall in are food for many insects that fish eat. Keeping sediment out of the water helps fish eggs and young survive.

The forest is a place for birds and other animals to live. We have destroyed wild habitats with farms, housing developments, factories, and shopping centers. Many animals can survive with us if they have a bit of wild habitat in a forest for themselves. Forests are good places for people, too.

Chesapeake Challenge

1. Make a list of some of the animals that you guess might live in a forest along a stream.

2. Design an ad for a newspaper or magazine that "sells" the value of forest strips along streams.

Family Action

1. Call your local agricultural extension service (listed under county government in your phone book) to find out how your family can help plant forest buffer strips.

Chesapeake Challenge

1. Use your reading in this book to find one other thing that you can do to help the Bay and its rivers.

Family Action

1. Make recycling a family project. For information on where you can take aluminum, glass and paper for recycling call these toll free numbers:

Maryland 1(800) 492-9188;
Virginia 1(800) 533-7488.

What Can Just One Kid Do?

Saving the Bay is a big project. What hope does just one kid have of really helping? You might be surprised. You can change a few things that you do every day to help. You can also teach your parents and brothers and sisters things that they can do. You can get your Boy or Girl Scout troop, church youth group, or 4-H club involved in projects to help the Bay.

Things to do by yourself:

1. Use less water. Turn the water off while you brush your teeth, take short showers or shallow baths.

2. Never litter, always throw trash in a trash can. Trash on streets and roads gets washed into streams, rivers and the Bay.

3. Protect the watershed. Do not use things that make a lot of trash that has to go in landfills. Pick fast food restaurants that use paper rather than plastic and styrofoam.

Things to do with your family:

1. Save water. Do not run the washing machine or dishwasher unless it's full. Do not leave the water running while washing dishes. Do not overwater the lawn or leave the hose running while washing the car.

2. Reduce the kinds and amounts of household chemicals you use. Most people use more than needed. Read the labels. If something hurts people, it will not be good for the Bay.

3. Dispose of oil from the car by taking it to a recycling station at a gas station. Never dump chemicals in your home drains or storm drains.

4. If you have a yard, prevent erosion and encourage water to soak in by planting plants and letting the grass grow longer. Sidewalks and driveways made of things like brick or gravel let the rain soak in, not run off.

5. Recycle trash, especially things that will not decay in a landfill. Ask for paper bags rather than plastic at the grocery store. Newspaper, glass and aluminum cans may be recycled. Use a compost bin to recycle leaves and grass clippings rather than send them to the landfill.

6. Vote for politicians and laws that are good for the Bay.

7. If you live on a farm, contact your soil and water conservation district about a conservation audit. They can help make your farm a better place for the Bay.

Parent/Teacher Information

Instructional Strategies, Answers and Information

This booklet is written for either home or classroom use as a children's reader with content and thinking skills questions for each topic. It is appropriate for a range of age levels from upper elementary to middle school, depending on the reading level of the children using it. It is written so that each page stands alone as a content-based lesson on some aspect of the Chesapeake Bay and its watershed. The topics are arranged in what the author feels is a logical sequence, but teachers and parents are free to rearrange them. ***Living in Water***, a classroom-based, hands-on approach, aquatic science curriculum, is a companion to this booklet for use in classroom science instruction. Contact the Department of Education and Interpretation, National Aquarium in Baltimore to order a copy. Suggestions for its use with this curriculum are given below.

Research proves that children benefit from working together in groups. If possible, have children work on some of the Chesapeake Challenges together in groups of two to five. Children also learn better if concepts are reinforced with discussion in which they play a major role, not as listener, but as contributor. Remember to give them plenty of "wait time" to think of answers rather than demanding instant responses. Follow-up discussion questions are suggested below along with answers to the Chesapeake Challenges.

The End of the Last Ice Age *(page 4)*

1. Check colored map on page 5.

2. 8,000 years ago homes were farther from the Bay as it was just beginning to fill.

Discussion: If you have a map of the United States showing depths offshore, ask the children to compare the shape of the USA when sea level was 100 m lower with the shape and size today. Note that the continental shelf is very narrow on the west coast, so it would not have been as different as the east and gulf coasts.

Living in Water: What was the climate like on land when compared to that in the ocean during the Ice Ages? Do Activity 10 to discover that living in the ocean reduces extremes of temperature.

Climate Change in the Future *(page 6)*

1. 60 times 2.5 cm = 150 cm or 60 in or 5 ft

Discussion: How many children have been to the beach in the summer? What will happen to the beach? The waves will wash over the barrier islands that form the beaches for most of the eastern USA. Other beaches may form farther inland but places like Ocean City and Virginia Beach will be lost.

The Land Changed as the Bay Formed *(page 7)*

1. Plants and animals become extinct because of rapid changes in climate or habitat. Plants and animals may also be hunted or killed to the point of extinction by people.

2. The climate changes due to the greenhouse effect may be so rapid that the plants cannot migrate fast enough and will die out.

Discussion: Can the students think of any other things that could cause extinction? One is the introduction of new species which crowd out the natural ones. Another is habitat destruction by humans.

The First Americans: Changing Ways of Life *(page 8)*

1. Water supply, animals to hunt such as fish and deer, plants to forage for such as nuts and berries, a level site protected from the weather and enemies, materials for housing, wood for cooking, access to water and trails for travel and trade, raw materials for weapons and handcrafts such as baskets and pots, and good soil for crops are some things you would need.

2. Play games with other children, sing songs, make up poems in your head, decorate objects with pretty designs, watch wildlife, go swimming, etc.

Discussion: Are these things still important today? What else might be added today?

The Chesapeake Bay as Seen by the Europeans *(page 9)*

1. He names fish, crabs, and oysters.

2. He thought they did all the hard work. Women in colonial America also worked hard, but men helped with agriculture and other tasks. Today women have the opportunity to do "men's work," but still have to fight the stereotyping of women's roles. Evidence is likely to be personal and vary with the child.

3. For once spelling is more flexible. Look for imagination. Share particularly good ones with the class.

Discussion: Do you think Captain Smith liked what he saw of the Chesapeake Bay and its inhabitants? Yes. Let the children give their evidence from the readings. Consider that he was writing to encourage more people to move to Virginia.

Native Americans of the Chesapeake Bay Region *(page 10)*

1. Indian names are too numerous to list. For example, most of the major rivers bear Native American names.

2. Answers vary.

3. Use sticks in modeling clay with clear plastic wrap for the surface of the water. Include modeling clay fish.

Discussion: Were the Indians clever in their ways of catching animals from the Bay for food? Yes. Give evidence from the reading.

Native Americans and their Environment *(page 11)*

1. Have children read some of the stories in class.

2. Many of the uses are the same, but there were many fewer Indians than there are people today so they did much less damage. Also, we have new technology like plastic nets which allow us to catch nearly every fish.

Discussion: Why did the Native Americans put up with the new arrivals from Europe? The reading does not discuss the fact that the Indians did not feel they owned the land and so were willing to share at first. Their numbers declined rapidly because they did not have weapons as effective as the Europeans and because they died from diseases the Europeans brought.

The Chesapeake Bay and its Watershed *(page 13)*

1. Maryland, Pennsylvania, New York, Virginia, Delaware, and West Virginia.

2. Check map on pages 30 and 31.

3. Western shore. More watershed for runoff.

Discussion: If a watershed is a natural unit, why are the state lines in such unnatural places? Because the colonies were divided up in Europe and because rivers formed boundaries, leaving two states sharing a river to fight over.

The Chesapeake Bay Watershed *(page 14)*

1. Water runs in realistic patterns.

2. Water collects in smallest crinkles first and then in ever larger ones, just as water on land runs into streams which form rivers which run into the Bay.

3. Nutrients end up in the Bay.

Discussion: Give evidence from the demonstration that a watershed is important to rivers and the Bay. The water from one becomes the other.

Living in Water: Activity 1 experiments with things that dissolve in water.

The Chesapeake Bay's Salt Water *(page 15)*

1. The Bay's salinity is lowest when rainfall is highest. Usually this occurs in the late spring although a hurricane in late summer or fall may also lower the salinity.

2. Check the map on pages 30 and 31.

3. Water at bottom of Bay at its mouth; water at surface of the Bay at its mouth; water at surface at mid-Bay; water at surface at the Susquehanna River.

Discussion: Have any of the children ever seen the mouth of the Bay where the salt water enters the Bay? If they have been across the Chesapeake Bay Bridge and Tunnel in Virginia, they have.

Living in Water: Activities 3, 4, and 5 detail the relationship of salt to fresh water in an estuary. Activity 6 is a contest that tests for understanding of the concepts.

What is Special about an Estuary? *(page 16)*

1. The mouths of most rivers where they flow into the sea form estuaries as well as the areas behind barrier islands along the coast. A few examples would be San Francisco and San Diego Bays in CA, the mouth of the Mississippi River in LA and TX, Pamlico Sound in NC, the Hudson River in NJ and NY and the St Lawrence River.

Discussion: How many of the places the children mentioned are large ports with big cities? Can they predict whether this is good for the estuary? No. They will probably cite pollution.

Living in Water: Activity 8 demonstrates what happens when plant nutrients are added to water.

Tides in the Chesapeake Bay *(page 17)*

1. Answers depend on location.

Discussion: Has anyone ever visited the ocean and observed the action of tides there? Look for statements about water moving up and down the beach.

Chesapeake Habitats *(page 18)*

1. Oyster beds, grass beds.

2. Sandy beach, marshes.

Discussion: Have the students ever visited one of these habitats in the Chesapeake Bay? Have them describe it.

Living in Water: Activity 2 reinforces the concept of habitats and introduces the students to some aquatic habitats not associated with the Bay.

Classifying Habitats of the Chesapeake Bay *(page 19)*

1. Check answers: 1. rocky shore 2. shallow water 3. seagrass beds 4. tidal freshwater marsh 5. mud flat 6. oyster bar 7. open water 8. sandy beach 9. weed beds 10. salt marsh 11. forest

2. 3. and 4. vary.

Chesapeake Bay Food Chains *(page 23)*

1. a. algae on mud, snail, diamondback terrapin

b. phytoplankton, zooplankton, small fish, large fish, large bird (osprey)

2. bottom: underwater plants and phytoplankton

middle: zooplankton, small fish

top: fish-eating birds, larger fish

Discussion: Ask the children to compare a Bay food chain with one on land such as an open field where there is grass, rabbits and hawks. In each identify the producer of food (plants), the animals that eat plants (herbivores) and the animals that eat other animals (carnivores).

Living in Water: Study aquatic food chains in Activities 28, 29 and 30.

Zooplankton in the Chesapeake Bay *(page 24)*

1. The copepods are all about 1mm. The water flea is 0.4mm.

2. *Podon, Eurytemora, Acartia, Scottolana.*

3. Look for understanding of the concept of drifting with currents or tides in each paragraph.

4. Zooplankton can be collected in a plankton net made with a pair of panty hose and a hanger or with a proper net. See biological supply catalogs. Live zooplankton can be projected with a 35 mm slide projector, using deep well projection slides from Carolina Biological Supply. See *Carolina Tips*, July, 1988, for details.

Living in Water: Learn about the characteristics of fresh and salt water as they relate to zooplankton and phytoplankton positions in the water in Activities 19 and 20. Activity 23 studies small animals that are not zooplankton, but are also prey for fish.

Blue Crabs in the Chesapeake Bay *(page 25)*

1. From the Patapsco it is roughly 425 km or 280 miles round trip. From the Rappahannock it is roughly 150 km or 100 miles.

Discussion: Why do the females swim all that way? Two possible answers might be that the larvae require the salinity found at the mouth of the Bay and that the food they need is there.

Oysters *(page 27)*

1. The plan requires correct salinity, a hard place to attach where they will not be buried in mud, the correct algae in the water and time to grow undisturbed. Freedom from disease and predators would be nice.

2. 1880: about 15 million bushels; 1920: about 5 million; 1980: about 3 million.

3. With oysters gone, other things that feed on phytoplankton benefit such as clams and the fish called menhaden.

Discussion: Why did the fishermen take too many oysters? Greed and ignorance might be two answers.

Atlantic Menhaden *(page 28)*

1. Oysters.

2. Check map to make sure the fish come in from the ocean and go into almost fresh water before leaving again.

Discussion: Currently, there are plenty of menhaden in the Bay. Should there be any limit on how many are caught? We might want to learn from past mistakes with other species and regulate the fishery before it is in trouble. Also, menhaden are important food for other fish which we want to catch like bluefish and striped bass.

Living in Water: Do Activity 21 on fish anatomy.

Striped Bass *(page 29)*

1. About 1100 km or 750 miles; estimates vary.

2. at least 11 states (North Carolina, Virginia, Maryland, Delaware, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine) and 2 provinces (New Brunswick and Nova Scotia)

3. pH as low as 3 has been measured in Maryland rain.

4. Acid rain is a result of combustion of fossil fuels (some kinds of coal and oil) rich in sulfur. Electric generating plants and steel mills produce air pollution that causes acid rain. Internal combustion engines such as those in cars and trucks that reach high temperatures also make air pollution that becomes acid rain. Acid rain can be reduced by reducing sulfur and nitrogen compounds in air pollution. Burning low sulfur fuel helps. Washing the fumes that go up smoke stacks helps. Public transportation that reduces use of cars can help.

5. Check map to make sure that striped bass go into low salinity water and return to the ocean.

Discussion: Much of the acid rain that falls in Maryland is the result of air pollution in the mid-western states. At what level would regulations have to be made to correct this problem? The federal government. Our acid rain kills trees and fish in Canada too, so international politics are also involved.

Living in Water: Activity 16 is a game that models the life of herring which, like striped bass, are fish that go out into the ocean to feed, but go up rivers to spawn. Students will learn about the causes of death during this reproductive cycle, including those caused by humans.

Living in Water: Visit the National Aquarium in Baltimore to see striped bass in the Migrating exhibit and do Activity 24 which studies the way fish swim.

European Settlement of the Chesapeake Bay *(page 33)*

1. Check map locations.

2. Both are on peninsulas of land in the southeastern corner of the state. The capitols were moved to more centrally located places later to improve access for citizens and legislators.

Discussion: What conditions would cause people to risk going to a new place across the ocean? Some came looking for wealth: gold, silver, gems and furs. Some came to escape religious persecution. Some came because they were very poor and seeking a better life. Some were criminals who were exported from England under force. Some were relatively well-to-do, but second or third sons who could not inherit the family land in England. Here they could become land owners as their older brothers were in England. A few were true explorers or scientists who wanted to discover new places, plants, animals and people.

Growing Tobacco *(page 34)*

1. Check the graph.

2. Rolling Road is a common name in many communities along the Bay shores and lower rivers. In Baltimore, Rolling Road runs north and south along the western edge of town.

Discussion: Today tobacco is under attack for reasons not associated with erosion. Why? Smoking is a serious health risk.

The Force of Moving Water *(page 35)*

1. The "sail" in bare dirt becomes splattered with mud. This soil would wash away in a storm. Grass protects the soil from erosion.

2. A "hard" rain causes more erosion than a "gentle" rain. The steeper the slope, the greater the amount of erosion.

3. Rocks and gravel settle to the bottom promptly while tiny dirt particles remain in the water much longer. This sediment helps make the Bay look dirty.

Discussion: If you were a farmer, how would you plan your fields to reduce the loss of your valuable soil? Avoid farming slopes. Keep plant cover as much as possible. Make furrows go across the slopes to stop runoff.

Living in Water: Start Activity 8. This activity should be completed with pages 48 and 49 of this booklet.

Using Water Power *(page 36)*

1. Check map and list.

2. The secret to the design of a good waterwheel is to have a heavy wheel that has a lot of inertia of movement once it gets going, much as does the flywheel of a motor or a spinning wheel.

3. Check map and list.

4. A good model fish ladder has many small jumps with places to rest in quiet water occasionally and takes a looping path around a dam or other obstruction to a river.

Discussion: Are the students aware of any controversial dam projects? Why might people oppose the construction of new dams? People who raft, canoe or kayak want wild rivers. Biologists worry about fish that need to swim upstream. Farmers do not like having their farms taken away and flooded. Foresters may oppose flooding forests along rivers. Dams may destroy habitats of endangered species.

Living in Water: Do Activity 22 to study the effect of depth on the force of water pressure.

Travel and Trade in Early Times *(page 37)*

1. Check map for fall line. Fredericksburg, VA, Baltimore, MD and Havre de Grace, MD.

2. Check map.

Discussion: Could the students live where they do if travel by boat were the only means of transportation other than walking or riding a horse along narrow paths? Some will say yes, but most will not. Discuss other means of transportation and how they might have influenced settlement: roads, horsedrawn wagons, railroads, trolleys, bicycles, buses and cars.

Living in Water: Activity 19 examines what makes things float or sink, very important traits in boats.

Working Boats and Ships of the Chesapeake Bay *(page 38)*

1. Answers on reverse side of cards.

Discussion: Boats and ships are technological applications of an understanding of water, wind and power. What evidence in the cards did the students find for changes in technology with time? Increased size, better streamlining, new materials, better sail design, use of steam and combustion engines for power.

Fishing the Bay *(page 42)*

1. The answers change with time as the laws may change each year. For example, when this was written, Maryland had a moratorium on fishing for striped bass and Virginia did not. Oysters come from leased beds in Virginia while the oyster beds in Maryland are common property. Virginia allows the taking of female crabs carrying eggs; Maryland does not.

Discussion: Does it make sense for two states which share a common resource to manage it in such different ways? Probably not, but many of the management laws are based on politics, not biology.

Habitats in the Chesapeake Bay Watershed Today *(page 44)*

1. Answers on backs of cards.

2. Answers on backs of cards.

Discussion: Which habitat do your children live in? Would they prefer to live in another? Why?

Muddy Water *(page 48)*

1. The water gets very dark with "sediment". This models non-point source pollution which enters the water with runoff and is very hard to control because it is hard to figure out where it came from. Pesticides and fertilizer are examples of non-point source pollution.

Discussion: Have your children seen examples of muddy water? Have them discuss where and when. Had it rained recently?

Living in Water: Complete Activity 8 with this lesson.

Too Many Nutrients *(page 49)*

1. Nutrients come from: sewage from cities or towns, septic tanks in rural areas, sewage from boats or ships that is not disposed of properly; manure from farms; and fertilizer from lawns in cities, towns or rural areas and from farms. Industries may contribute a bit as do forests.

2. Forests absorb nutrients but also release some.

Discussion: Have the children identify ways they contribute to the Bay's nutrient load. Sewage is the main way, but there are others based on where they live.

Living in Water: Activity 8 and 9 relate directly to this topic.

Toxic Materials in the Bay *(page 50)*

1. Every habitat except forests. Farms with animals may use fewer toxic chemicals.

2. This models the pollution that comes from a factory or sewage plant which has a specific source and is called point source pollution. It ends up in the Bay.

Too Many Phytoplankton and No Oxygen *(page 51)*

1. Low oxygen is most likely to occur in deep water where there is salty water on the bottom and fresh water on top. This layering is called a stratified system.

Discussion: Have the children ever seen a pond covered in algae? It forms green mats.

Living in Water: Activities 1, 3, 4, 5 and 15 relate to the formation of layered or stratified conditions in bodies of water. Activities 11, 12, 13 and 14 study the use of oxygen by plants and animals as well as the relationship of oxygen in water to temperature.

Lost Underwater Grass Beds *(page 52)*

1. Answers vary. Look for predators and escape among grasses.

Discussion: Have the students work together to list all the kinds of animals that benefit from underwater grass beds, also called submerged aquatic vegetation.

Living in Water: Activity 27 proves that light is important to underwater plants.

The Problem is People *(page 53)*

1. Have students compare and critique designs.

Discussion: The states of Maryland, Virginia and Pennsylvania and the District of Columbia along with the U.S. Environmental Protection Agency released a report in December, 1988, from a committee called Year 2020 Panel. It predicted a population growth of 20% by the year 2020. The report called for limits and regulated development. Who might oppose this? People who make money from development.

Living in Water: Activity 28 and 29 examine population growth and controls in natural populations. Compare them with human populations.

Meeting the Challenge *(page 54)*

1. Check the letters for spelling and content.

Discussion: Compare the answers students got from different organizations. Did they all agree?

Forests to Help the Bay *(page 55)*

1. Many kinds of birds from tiny wrens and nuthatches to hawks and owls, deer, raccoons, opossums, foxes, squirrels, chipmunks, rabbits, snakes, lizards, insects and others. Many animals like rabbits and deer hide in cover during the day and feed at dawn and dusk or at night.

2. Check work and share with other children.

Discussion: Where are the nearest forests? Are they just in outlying areas? No. They are also in parks, along roads and freeways, around the airports and factories, along rivers running through towns and other places.

What Can Just One Kid Do? (page 56)

1. Answers vary. Encourage ideas about career options that contribute to the Bay, from politicians to wildlife biologists to teachers.

Discussion: Have each child write a pledge on a card that the child promises to undertake to help the Bay. They do not have to be signed. Post them for others to see.

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These are just a few of the many organizations working to help the Chesapeake Bay.

United States government

Soil Conservation Service
Chesapeake Bay Liaison Office
410 Severn Avenue
Annapolis, MD 21403

Estuarine Programs Office
Department of Commerce
F/EPO - Universal Building
1825 Connecticut Ave. NW
Washington, DC 20235

National Marine Fisheries Service
1825 Connecticut Ave., NW
Washington, DC 20235

U. S. Fish and Wildlife Service
180 Admiral Cochrane Drive, Suite 535
Annapolis, MD 21401

U. S. Environmental Protection Agency
Chesapeake Bay Liaison Office
410 Severn Ave.
Annapolis, MD 21403

Citizen Organizations

Chesapeake Bay Foundation
162 Prince George Street
Annapolis, MD 21401

Alliance for the Chesapeake Bay
6600 York Rd.
Baltimore, MD 21212

Save Our Streams
263 Scotts Manor Dr.
Glen Burnie, MD 21061

Council on the Environment
903 Ninth Street Office Building
Richmond, VA 23219

Maryland government

Governor's Chesapeake Bay Coordinator
State House
Annapolis, MD 21401

Department of the Environment
2500 Broening Highway
Baltimore, MD 21224

Department of Natural Resources
Tawes State Office Building
Annapolis, MD 21401

Department of Agriculture
50 Harry S. Truman Parkway
Annapolis, MD 21401

Department of Education
200 W. Baltimore Street
Baltimore, MD 21201

Virginia government

Department of Forestry
P.O. Box 3758
Charlottesville, VA 22903

Department of Health
109 Governor Street
Richmond, VA 23219

Department of Natural Resources
9th Street Office Building
Richmond, VA 23212

Commission of Game and Inland Fisheries
P. O. Box 11104
Richmond, VA 23230

Virginia Marine Resources Commission
P.O. Box 756
Newport News, VA 23607

Pennsylvania government

Pennsylvania Department of Agriculture
2301 N. Cameron Street
Harrisburg, PA 17110

Office of Environmental Education
Pennsylvania Department of Education
333 Market Street
Harrisburg, PA 17126

Pennsylvania Department
of Environmental Resources
P. O. Box 2063
Harrisburg, PA 17120

Pennsylvania Fish Commission
P. O. Box 1673
Harrisburg, PA 16105-1673